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ARTICLES

DIGESTION IN THE RUMINANT

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In 1844, Flourens, a French physiologist, published the results of experiments on goats, designed to answer three questions, the first of which was: "Into which part of the stomach does food pass when it is first eaten?" His answer to this question, given in a few words, was as follows: "*Tout le monde convient qu'ils vont dans le premier estomac.*" The emphasis which Flourens placed upon the rumen as the first receptacle into which food passed is complementary to investigations that were carried out in Germany about the same time by Haubner (1837) who showed that cattle and sheep digested large quantities of "crude fibre," an important constituent of the food. The association of the rumen and the digestion of "crude fibre" provides the key to the peculiarities of digestion in the ruminant, and it is from this association that subsequent research has grown.

"Crude fibre," which is a fair measure of cellulose, was found by Kellner (1900) to be of equal value to starch when it was fed in a purified state to steers, and this fact has led to much speculation and research to explain how it is that cellulose, which is digested by bacterial enzymes, and starch, which was assumed to be digested in the normal way, can provide the animal with an equal number of calories. It is perhaps unfortunate that so much emphasis has been placed upon the fermentation of cellulose in the rumen for, although the ability of the ruminant to digest so much of this material is the outstanding peculiarity of its digestive system, it has led to the view that all other constituents of the diet are digested in the usual way. According to this conception, the cell walls of the herbage are dissolved by the action of bacterial cellulases in the rumen so that the contents of the cell are exposed to the digestive juices when the food passes to the abomasum and small intestines. This idea, however, ignores the characters of a mixed population of micro-organisms such as that which inhabits the rumen and is too rigid to be true. Bacteria, in common with all living things, need both energy and nitrogen, apart from minerals and growth factors and, as effective digestion of an insoluble material such as cellulose is impossible without bacterial growth, it is logical to suppose that part at least of this nitrogen is supplied by the food. It is true to say that the bacteria and, for that matter, other organisms in the rumen, live upon the food eaten by the ruminant and that any foodstuff that enters the rumen is liable to bacterial attack.

The Fate of Carbohydrate and Nitrogenous Compounds in the Rumen

No one can say how much of the food that enters the rumen leaves it again and passes to the abomasum and small intestine unscathed. There is, however, some information concerning the quantity of cellulose and pentosans digested. Lignin has proved a useful constituent of the food in obtaining this information for, as it is sparingly, if at all, digestible, it can be used as a marker against which to compare the disappearance of the digestible constituents of the food. Its use is applicable, however, only when feeding a single foodstuff of which lignin forms an integral part, such as hay. By comparing the proportion of lignin to cellulose in the food to the proportion found in the rumen and in the fæces, it has been calculated that 85 per cent. of the digestible cellulose disappears from the rumen of a cow fed on alfalfa hay within 14 hours and that additional digestion in the rumen after the 14-hour period is negligible. In sheep fed on wheat straw chaff and hay, or on chaffed meadow hay, 70 per cent. of the digestible cellulose disappears in the rumen, the remainder disappearing for the most part in the large intestine. It has recently been shown that digestion of pentosans in sheep follows a similar pattern to that of cellulose and approximately 70 per cent. of the total digestion is over when the food reaches the abomasum (Marshall, 1948).

Normally, the amount of hexose sugars contained in the food is small, but the rate at which glucose can be fermented in the rumen of sheep fed on a mixed ration is indicated by the fact that 100 gm. of glucose introduced into the rumen disappears so rapidly that little is left at the end of 3 hours and none at the end of 4 hours. The amount passing to the abomasum appears to be small as the concentration in the abomasal contents does not increase significantly, while there is every sign of intense fermentation within the rumen. Rapid fermentation also follows the introduction of cane sugar, maltose and fructose. Young pasture grass is the most valuable foodstuff on the farm and it may contain a large quantity of soluble carbohydrate, for Norman & Richardson (1937) found that 26 per cent. of the dry matter of ryegrass cut in May consisted of fructosan (a water-soluble polysaccharide made of fructose units), and other water soluble sugars were also present in smaller amounts. The speed with which glucose disappears makes it appear unlikely that all these materials will escape fermentation in the rumen.

The position with starch is clear as it has been observed microscopically that iodophilic cocci surround and disintegrate starch granules in the rumen and themselves become loaded with a polysaccharide which stains blue with iodine. In addition, the introduction of starch into the rumen results in the production of volatile fatty acid although the increase is small compared to that obtained when glucose or fructose is added to the rumen. The reaction, however, is greatly increased if casein is given in addition to starch.

All the principal carbohydrates, therefore, which may be contained in the diet are potential sources of energy for the bacterial population; we can say with confidence that some of each individual carbohydrate

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will be fermented, but we cannot say, except with cellulose and now pentosans, that a given amount of starch or hexose will be fermented in the rumen and that a given residue will pass to the small intestine.

Little is known about the fate of the proteins of the food in the rumen, but there is evidence that casein is attacked, for the introduction of this protein into the rumen results in an increase in the concentration of ammonia in the rumen fluid. In order to understand the significance of ammonia it is necessary to discuss the utilization of nitrogen given in non-protein forms. The idea advanced is that bacteria in the rumen are able to use non-protein nitrogen for growth so that there is an increase of bacterial protein in the rumen at the expense of non-protein nitrogen of the food. If the bacteria are digested in the small intestine then the animal benefits from the transaction. Many simple nitrogenous compounds, such as glycine, have been investigated as sources of nitrogen, but recently, however, urea has received most attention and under suitable circumstances urea can replace about 40 per cent. of the protein of the ration both for growth and milk production, provided a readily available source of energy (such as starch) is also provided.

Urease is an enzyme present in the rumen for it is produced by widely distributed bacteria, *proteus* for example, which is a regular inhabitant of the rumen. The introduction of urea into the rumen liquor results in its rapid hydrolysis with the production of ammonia. Ammonia, however, does not persist and as it disappears so the quantity of protein increases. This increase has been shown to go hand in hand with an increase in the numbers of bacteria. This is not an unphysiological event; it is only an exaggeration of a normal process, for appreciable quantities of urea (10 mg. urea N per 100 ml. saliva) are present in the saliva of sheep, and as the quantity of saliva secreted per day may amount to several litres, urea is a source of nitrogen continually entering the rumen, providing ammonia for bacterial growth (Macdonald, 1948a). The production of ammonia from casein, to return to digestion of protein, is an indication that deamination is occurring in the rumen and that bacteria are growing at the expense of nitrogen obtained from casein. The same effect can also be obtained, but to a less extent, with gelatin, but the introduction of zein, an insoluble protein in the rumen liquor, produces no appreciable response. These facts show that the nature of protein concerned influences its availability as a substrate for the bacterial enzymes, and allows interesting speculations to be made concerning the fate of different food proteins in the rumen (Macdonald, 1948b).

The Results of Fermentation in the Rumen

The temperature of the rumen rises two or more degrees Fahrenheit above body temperature during fermentation so that a certain amount of the energy of the food is expressed finally as heat. The warmth so provided must be of considerable comfort to the animal and is probably of value in maintaining body temperature, but apart from this the value of fermentation to the host will be determined by the quantities and nature of the chemical products of fermentation and by the quantity and food value of the micro-organisms which grow in the rumen.

The free chemical substances that are known to be produced as a result of fermentation are the gases, methane and carbon-dioxide, a mixture of lower fatty acids, and ammonia. Of these methane is a waste product and a loss of energy to the animal. Forbes estimates that the quantity evolved represents from 4 to 5 per cent. of the digestible carbohydrate of the ration. The quantity of carbon dioxide produced is considerably greater than that of methane, but as part of it is produced from bicarbonate in the saliva, which neutralizes the organic acids formed in the rumen, it is impossible to say how much of the carbon of the food is represented by the carbon dioxide evolved in the rumen.

The acids produced in the rumen are acetic, propionic and butyric acids, and traces of a higher acid are sometimes present. The proportions are characteristic of fermentation not only in the rumen but also of fermentation in the large intestine of the horse, pig and rabbit. Acetic predominates and forms on an average 60-65 per cent. of the total in animals that are true herbivores, while larger quantities of propionic or butyric acids exist in the cæcal contents of the rat. The total quantity of lower fatty acid, expressed as acetic acid, present in the rumen and reticulum of sheep taken from pasture was found to vary from 27 to 91 gm. Figures of 250 and 350 were found in the organs of two oxen.

There is little information concerning the quantity of microbial protein that can be found in the rumen. In cattle an average figure of 404 gm. has been estimated to be present in the liquor alone and this figure ignores those organisms which are adherent or caught up in the solid material of the rumen. Analysis of the rumen liquor of sheep has shown that 80 per cent. of the dry matter can be accounted for by ash, volatile acids and protein, but it is not known exactly how much of the protein is due to micro-organisms and how much to minute fragments of plant tissues, for the difficulty of separating particles approximately of the same size and same specific gravity has still to be solved. All that can be said is that as far as can be judged from the appearance of rumen liquor under the microscope, bacteria are preponderant in sheep fed on hay.

The Fate of the Products of Digestion in the Rumen

Three pathways exist by which materials leave the reticulum and rumen; they may pass up the œsophagus to the mouth; they may pass to the omasum and then to the abomasum and intestines or they may be absorbed from the rumen into the lymphatic and blood streams.

It is common knowledge that digesta pass to the mouth during rumination every time the animal regurgitates but the bolus of the re-mastication when it is swallowed passes back again to the rumen. The fluid part of the material that is regurgitated, however, is swallowed again as soon as it reaches the mouth and there are no data available to show whether this, in common with the bolus, returns to the rumen or whether it passes via the œsophageal groove to the omasum and abomasum. Gases from the rumen are regularly regurgitated and are excreted to the air, but absorption also occurs.

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The material that passes to the omasum consists of food residues, bacteria, protozoa, and other organisms suspended in a solution which contains, besides minerals, fatty acids and ammonia. The quantity leaving the reticulum and rumen in twenty-four hours is unknown, but there is evidence to show that the flow from the stomach occurs at frequent intervals throughout the daylight hours.

Of the micro-organisms the protozoa do not survive the acidity of the abomasal contents and microscopic examination shows that the protozoa in the material entering the duodenum are in an advanced state of disintegration. There is less positive knowledge concerning the fate of the bacteria; although the fact that urea can replace part of the protein in the ration suggests that bacteria are digestible. Dried bacterial protein from the rumen is known to be digested by rats.

Nutrients known to be absorbed from the rumen are acetic, propionic and butyric acids, while ammonia and carbon-dioxide have also been found in the blood draining the rumen in excess of that draining the remainder of the alimentary tract. Some ammonia therefore escapes utilization by bacteria and must be considered as a loss to the animal, for in the liver it is formed into urea, although salivary urea compensates to a certain extent for the loss of nitrogen from the rumen due to absorption of ammonia. Fatty acids are also absorbed from the rumen and reticulum and also to a less extent from the omasum. The rate at which these acids disappear is influenced by the acidity of the rumen contents, and absorption increases at a given concentration of fatty acid as the pH decreases. The quantity absorbed when expressed as acetic acid is not less than 1-5 gm. an hour in sheep fed on pasture grass.

Acetic is the acid present in greatest quantity in the blood draining the rumen as it is also in the rumen contents. These acids are not only metabolized, for the quantity appearing in the urine is negligible, but they are rapidly metabolized, for the concentration in the peripheral blood is very small while the large heat increment which follows feeding in the ruminant is too large to be accounted for by the protein of the diet and is probably due not only to the heat of fermentation generated in the rumen but also to the metabolism of fatty acids. Propionic acid is known to form glucose in the liver and so is a source of carbohydrate. Acetic acid, besides being directly oxidised, may be included in long chain fatty acids and so form fat; or it may form glucose, at any rate in small quantities. The full metabolic rôle of acetic acid is only partially understood and it is sufficient to say here that other possibilities also exist. Butyric acid can follow the same metabolic patterns as acetic acid.

Special Constituents of the Bacterial Cell

It has frequently been observed that many of the bacteria in the rumen exhibit what is called the "Iodophilic Reaction." This, in plain language, means that they stain blue with iodine. Bacteria responsible for the disintegration of cellulose in the rumen invariably possess this characteristic, and it is more marked still in organisms which disintegrate starch granules. In addition, if glucose is introduced into the

rumen of a sheep which possesses a flora rich in iodophilic bacteria and a solution of iodine is added subsequently to the liquor of the rumen in a test tube, the iodophilic organisms are stained an intense blue. If the rumen liquor is tested in this way at regular intervals after the introduction of glucose it is found that the iodophilic reaction fails to appear about 12 hours after the addition of glucose. The reaction suggests that a polysaccharide similar to starch is formed inside the bacterial cell and it is known that subsequent hydrolysis of this "bacterial starch" yields reducing substances. The fact that it disappears as time proceeds means that it is metabolized by the bacterial cell. It seems likely that, when bacteria containing polysaccharide pass from the rumen to the abomasum and small intestines, the polysaccharide will be digested along with the bacteria by the pancreatic and intestinal enzymes of the sheep, and so form a source of carbohydrate. It is not known, however, whether the ruminant obtains a significant amount of carbohydrate from this source and it is important that this problem should be investigated.

Another valuable attribute of the bacteria in the rumen is their ability to synthesize the vitamin B complex. It has been known for a long time that it was not possible to produce symptoms of vitamin B-deficiency in adult cattle by feeding a B-deficient diet and there is abundant evidence now available to show that the flora in the rumen synthesize thiamin, riboflavin, nicotinic acid, biotin, folic acid, pantothenic acid and vitamin B₆ (pyridoxin).

The diet has some influence on the amount of vitamin B synthesized and there is evidence to show that readily available sources of carbohydrate and nitrogen, such as molasses and urea, increase the synthesis of all components of the complex except B₆. The addition of molasses and urea to the diet provides conditions suitable for the rapid growth of bacteria so that under these circumstances it is understandable that increased synthesis of a bacterial product should also occur.

There is no evidence to show that the fat-soluble vitamins are produced in the rumen with the exception of vitamin K, which occurs in many micro-organisms, particularly bacteria, and has been found to be present in abundance in the rumen of a cow receiving a deficient ration.

The Physiological Control of Fermentation in the Rumen

The environment in the rumen is maintained sufficiently constant to allow fermentation to proceed unembarrassed by an accumulation of end products. The conditions in the rumen are exceedingly difficult to produce artificially and for this reason no one has yet succeeded in inventing a method of imitating the rumen exactly *in vitro*.

The reticulum and rumen together form a fermentation chamber in which the solid food is collected and only allowed to pass on to the lower regions of the alimentary tract in a slow stream and then only when it has reached a sufficiently small size. Saliva and water enter the reticulum and owing to the brisk regular contractions of this organ, which occur about once a minute, fluid is washed backwards to the rumen, the contents of which is flushed with the fluid contents of the

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reticulum ; later, contractions of the walls of the rumen return the fluid to the reticulum. By this means the smaller particles of food are slowly separated from the mass in the rumen. The digesta entering the omasum comes from the reticulum and so contains small particles of food. The process of rumination, besides exposing a larger surface area to bacteria, also influences the rate at which they leave the rumen and the smaller the size of food particles the greater speed with which they leave the rumen.

The micro-organisms suspended in the fluid contents of the rumen are also continually passing from this organ to the lower part of the alimentary tract so that the population does not become " overcrowded " with viable bacteria or jeopardized by the presence of increasing numbers of dead and disintegrating micro-organisms.

The conditions prevailing are anaerobic, for the gas in the rumen is mostly carbon-dioxide and methane ; this state of affairs prevents the proliferation of aerobic organisms and is in itself an important factor in determining the types of micro-organisms that are active.

The reaction of the rumen contents is maintained on the acid side of neutrality with most diets. This is achieved by the continual inflow of saliva, rich in bicarbonate, which neutralizes the acids formed, and by the fact that fatty acids as such are absorbed more rapidly than the sodium salts so that, if the rate of formation of acid is too great for the buffering capacity of the rumen fluid, excess acid does not accumulate.

Continuity of fermentation is thus possible and as the ruminant, under natural conditions, feeds on and off throughout the daylight hours, the last condition necessary for continuity is supplied, namely, a steady replenishment of the substrates necessary for bacterial growth.

The benefits the animal obtains from this type of digestion are that it receives a continual supply of energy in the form of short-chain fatty acids and a continual supply of protein in the form of micro-organisms while the food it eats is enriched by B vitamins formed in the bacterial cell. The result is that the ruminant can live on coarse fibrous food-stuffs which otherwise would be incapable of supporting life except where, as in the horse, a similar train of events occurs in the large intestine. Even so, the ruminant is still better adapted to a purely herbivorous diet because the opportunities for the absorption of the products of fermentation leaving the rumen are obviously far greater than the opportunities of absorbing the products of fermentation in the large intestine.

Fermentation also occurs in the large intestines of the ruminant but, because of the small capacity of these organs compared to those of the horse, it is less important.

The disadvantage to the animal is that fermentation (compared to normal digestion) is a wasteful process since large quantities of energy are lost as heat and methane. In addition, since only a part of the potentially digestible material of hay or straw is fermented, the animal has to ingest a correspondingly greater quantity of food. This means that a greater proportion of the animal's time and energy must be spent in eating. With animals feeding entirely on fodders which would not

be of use to man, this is not a serious economic factor, but with animals consuming large quantities of foodstuffs, such as cereals, which can be used directly by man as food, the conversion factor of the foodstuff in question into useful animal products becomes an important economic consideration, particularly in times of world food shortage.

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NOTE. References are given either to very old literature quoted or to very recent publications, otherwise further references to other material contained in this review can be obtained from the review entitled, "The Role of the Microflora of the Alimentary Tract of Herbivora with Special Reference to Ruminants," *Nutr. Abstracts & Reviews*, 17 (1947/48), 1-37.

ABSTRACTS

ANIMAL BREEDING

Identical Twin Genetics in Cattle. Bonnier, G., and Hansson, A. Animal Breeding Institute, Wiad, Eldtomta, Sweden. *Heredity*, 2 (1948), 1.

Bonnier and Hansson estimate that there are about eight pairs of identical twins amongst a hundred equally sexed pairs, although there is some diversity of opinion amongst workers as to the exact numbers. However, as soon as it was known that identical twins really do occur, it was evident that they would be of immense value in experimental work. It was felt that it would now be possible to prove whether a high yielding cow from a herd with high feeding intensity was necessarily genetically better than a low yielding cow from a herd with a low feeding level.

The first experiments were started at Wiad in Sweden in 1937 and since then others using identical twins have been started at Ruakura Research Station, New Zealand (where there are 55 pairs of identical twins), in Norway, Denmark and Finland.

Diagnosis of identical twins is by no means easy, serological tests are valueless, and all tests must be based on morphological grounds. The following criteria seem to be of value, but unfortunately no single character is crucial:

- Marking and shade of colour.
- Number, position and direction of hair-whorls.
- Size, position and colour of eyes.
- Colour and shape of tails and especially of tail brushes.
- Colour and print of muzzles.
- Shape of udders, ears and heads.
- The way in which hairs cover different parts of the body.

The first tests are made when calves are only a few weeks old, and it may be necessary to discard a small proportion of pairs as being non-identical, as the characters show themselves at a later date.

It has been shown (Bonnier, Hansson and Düring, 1946) that twin experiments are at least twenty times as efficient as ordinary group experiments in the case of experiments on growth rates of young heifers, and it would seem fair to conclude that twin experiments are at least five times as efficient in the case of milk yields, though exact evidence of the latter is at present lacking.

Twin Experimental Plans

In the experiments the like twins are divided into equal groups, "A" animals being fed higher and "a" animals at a lower level.

Two systems of feeding have been adopted.

I. Feeding according to individual weight and yield.

II. Feeding related to "normal" feeding curves, the feeding curve being calculated according to the amount of feed required for an average heifer of the same age and breed.

The experiments being conducted with identical twins at the Animal Breeding Institute at Wiad, on effects of variation in the feeding intensity, are distributed in the following series :

(1) Prior to first calving, feeding "A" animals 33 per cent. above and "a" animals 33 per cent. below "normal," according to system I. From first calving all animals normally fed according to II.

(2) Prior to first calving, feeding according to II, "A" animals about 25 per cent. above and "a" animals 25 per cent. below normal. From calving, according to II, "A" animals 12.5 per cent. above and "a" animals 12.5 per cent. below normal.

(3) Prior to first calving, all animals "A" and "a" normally fed according to I. From first calving, according to II, "A" animals 12.5 per cent. above and "a" animals 12.5 per cent. below normal.

(4) Prior to first calving, all animals ("A" and "a") normally fed according to I. From first calving that animal which calves first being reckoned as an "A" animal and being fed normally according to I after first calving. Each separate "a" animal is then fed in relation to her "A" sister.

(5) Prior to first calving one of the twin sisters is reckoned as an "A" animal, and all "A" animals are fed normally and according to I. Each separate "a" animal is then fed in relation to her "A" sister, 60, 80, 120, 140 per cent. of the sister's feed amount.

Findings

Although the work is typical long-term work and has been going on for a decade, it is still in its initial stages. The following results concerning principles of how heredity and environment would appear to co-operate have become evident.

All experiments indicate that there exists a genetically determined "ceiling" in respect of all kinds of qualitative characters : this means that at all times of a cow's life there is a production maximum above which she cannot rise, irrespective of the amount of feed consumed.

There are considerable differences in the growth rate of "A" and "a" animals of each pair of twins, especially so when the rate of growth is measured as liveweight increase. There are marked differences between different pairs of animals, which include big differences between "A" animals.

It is believed that "A" animals have been given sufficient food to make their whole growing capacity, yet in one experiment there is 100 kilogrammes between "A" animals, although consuming the same food. The individual weights of the two pairs are "A" 482, "a" 344, and "A" 382, "a" 316 kg. respectively. In the same pairs, however, the height at the shoulder shows the two sisters "A" "a" and "A", "a" equal, although there is approximately 16 cm. between the pairs. This shows that heredity is of much greater importance in height than in liveweight.

In a similar experiment conducted with eight and nine pairs of identical twins, the increasing of the feed shortage from 25 per cent. to 33 per cent. below normal, passed the critical limit, and resulted in the "a" animals of the 33 per cent. group being about 10 cm. smaller than their "A" sisters.

ABSTRACTS : ANIMAL BREEDING

The same kind of results were obtained with regard to milk yield later in the same experiment, when the amount of food was lowered to 33 per cent. below normal, the amount of milk was considerably reduced, although feeding after calving was according to the individual weight and yield of the animal.

Five pairs of twins from a further experiment have been milked 36 weeks after calving ("A" animals 25 per cent. above and "a" animals 25 per cent. below, before calving, and $12\frac{1}{2}$ per cent. above and $12\frac{1}{2}$ per cent. below after calving). The average production (milk yield and increase in body weight) is practically equal for "A" and "a" animals. The difference between the milk yields of the different pairs is much more marked. In three pairs the "A" animals have yielded more milk than the corresponding "a" sisters.

In two of the pairs the converse is the fact, in one of these pairs the "a" animal gave 350 kg. higher milk yield but the liveweight gain was much lower, the other pair showed the "a" sister to have given more milk as well as an increase in body weight over her better-fed twin sister. This would seem to show that the ceiling limit of the latter pair lies below what corresponds to the "a" animal's feed consumption, and consequently the "A" animal of this pair had been heavily overfed. The overfeeding had disturbed the general metabolism of the animal to such a degree that she was unable to reach her true "ceiling." It would appear that an increase in the amount of feed above the ceiling level is not followed by an increase in production; and if the increase is very marked it may be followed by decrease. A decrease in the amount of feed below the ceiling level is followed by a decrease in production.

The "ceiling" forms the upper boundary of production. The most important aspects of production, as far as the cow is concerned, are milk yield and growth. How these different parts will be proportioned is perhaps impossible to predict, and it may be that they are determined by genetic factors.

If undernourishment falls below a critical level the effect on the animal will be severe, the gradient of nourishment apparently runs from the head backwards, the ceiling is reached with quite a low feed in the case of the width of head, with a somewhat higher feed in the case of the height at the shoulders, and with a still higher feed in the length of the sacrum.

Finally, it would seem that the feeding intensity may be such that, whereas the ceiling of the liveweight is not attained the ceiling of all body measurements are reached.

In the case of milking animals, so far as the experiments show at present, the "a" animals, which were decidedly undernourished prior to calving, have yielded less milk than their "A" sisters during the first lactation, but have made greater liveweight gains, consequently the difference in milk yield during the second lactation is less than in the first lactation, and the variation in yield due to heredity increases greatly from the first to the second lactation.

W.L.

ANIMAL HEALTH

Brucellosis (Contagious Abortion)

The important features in brucellosis are the highly infectious nature of the disease, the way in which it is spread and the methods by which it can be controlled. Pregnant cattle are highly susceptible and only small numbers of the causal organism, *Brucella abortus*, are required to set up an infection. The simplest and surest method of infecting is by placing a small number of the organisms on the eye. All infected cattle do not abort—some carry their calves to full term and animals which have aborted once do not usually abort again. It must be remembered, however, that all infected animals, whether or not they abort, excrete the infecting organisms at calving and continue to do so until all the discharges have disappeared. The discharges and the foetus and membranes of infected animals contain large numbers of *Br. abortus* and their contacts with susceptible, pregnant cattle are the important causes of spread of the disease. No matter what method of control is practised, it is essential that these sources of infection are recognized and that access to them and to anything contaminated by them is prevented. The organism is also found in the milk of infected lactating animals ; it is present at calving and in many animals disappears within a few weeks. Control by the recognition of infected animals, their removal from contact with healthy stock and the prevention of the introduction of infection from outside sources or through infected cattle is possible. Many herds have been cleared from the infection, but great difficulty is experienced in maintaining freedom from infection because of the prevalence of the disease throughout the country. In diagnosing the presence of infection use is made of the agglutination test. Infected animals react to the test as also do those which have been infected and have recovered. In controlling contagious abortion by the above method it is necessary, following the establishment of a herd free from reactors to continue testing periodically to ensure that further infection has not been introduced.

The more satisfactory method of controlling the disease is to render animals resistant to the infection by the injection of a suitable vaccine. Vaccines of different types have been used, but recent work has shown that a vaccine consisting of a suspension of living *Br. abortus* strain 19 organisms gives highly satisfactory results. This vaccine may be used on female bovines of any age provided they are non-pregnant, and evidence from the results of experimental work and observations in the field indicate very strongly that a high resistance is set up in injected animals and that it continues in a sufficiently high state to enable them to resist most infections for three or four pregnancies following a single dose. It is convenient to treat animals before the first pregnancy ; this is the so-called "calfhood vaccination." Calves under 4 months of age should not receive vaccine for they may fail to develop an immunity. Following vaccination animals become reactors to the agglutination test. The younger the animals are when vaccinated the sooner do they become non-reactors : in animals vaccinated at 4-8 months of age about 85 per cent. have become non-reactors and the

remainder react only to a slight degree by the time they reach breeding age. If it is desired to have a breeding herd free from reactors to the agglutination test, vaccination should be carried out at this age. Whether further doses of vaccine should be injected later in life must depend upon circumstances in the herd : veterinary surgeons, from a knowledge of the herd, can advise on this point.

Much has been written on the part played by the bull in transmitting this disease. A bull may be a mechanical carrier of the organisms if brought into contact with infected females, especially if they are still discharging after calving or aborting. The greatest danger, however, is the bull which is actually infected. Recent evidence shows that infection of the bull may be more common than was formerly believed. Infected bulls tend to become sterile, but they can cause much infection when at service. Clinical symptoms in the bull may not appear until the infection has been present for some considerable time, but infected bulls become reactors to the agglutination test and so can be diagnosed in the early stages. In the examination of bulls for use in artificial insemination centres, great stress is laid on their freedom from any evidence of infection with *Br. abortus* and periodical agglutination tests are carried out on them during all the time they are at the centre.

It is inadvisable to vaccinate bulls at any age for there is some evidence that the organism in the vaccine may settle in the genital organs.

T.D.

ANIMAL NUTRITION

Iodinated Casein

During the last fourteen years a number of papers have appeared both in this country and in America on the relationship between the activity of the thyroid gland and milk production. It has been demonstrated that casein, which has been iodinated under special conditions, has a definite thyroïdal activity and, when fed to lactating cows or goats, brings about a substantial increase in yield of milk.

Most of the earlier reports deal with trials in which the feeding of dried thyroid, iodinated casein or injections of thyroxine were carried out during relatively short periods. The results of these trials indicated that the treatments stimulated increased milk production and in many cases resulted in higher yields of milk fat. It is interesting to note that the stimulation to increase production of milk was accompanied in the animal by an acceleration of heart beat and sometimes by loss in body weight. In 1946 K. L. Blaxter (*J. agric. Sci.*, **36** (1946), 117) reported the results of an extensive series of experiments in which iodinated casein was fed to dairy cows on commercial farms in England and Wales. In all, trials were carried out with 102 different herds comprising approximately 1,000 cows. The paired feeding technique was used and the iodinated casein fed through the medium of cattle cubes (4 lb. per cow per day) which contained 11.2 kg. of iodinated casein per ton. One cow in each pair acted as a control and received normal feeding and management, whilst the other was fed and treated normally for a preliminary two-week period followed by a six-week period during which

the iodinated casein was fed : the treatment was then stopped and the cows received normal food again and were under observation for a further two weeks. Records were kept of milk yields, health, estimates of condition and, in certain cases, heart rates during the treatment. Where facilities were available measurements of liveweight were also made. These data have been analysed statistically and the following is a brief summary of the findings.

The feeding of the iodinated casein gave a mean increase in daily yield of 5.44 lb. during the third and fourth weeks of the experimental period. On an initial yield of 25.02 lb. this corresponds to a percentage response of 22.2 per cent. Differences of response between breeds were small relative to the mean response of all treated cows, but this was not uncomplicated. The response by heifers and young cows was less than that of mature cows and the author suggests that this is due to the higher level of metabolism of the former. An analysis of the response to the feeding of iodinated casein at different stages of lactation indicated that the response was greater as lactation advanced. It would seem that the main factor in the variation in response is concerned with the functional state of the tissue of the mammary glands as indicated by the initial yield and stage of lactation. Observations made during the last fortnight, that is during the period immediately after the feeding of iodinated casein was stopped, showed that yields remained high for several days and then dropped severely. This fall in yield was not so abrupt when the dosage of iodinated casein was reduced gradually. So far as condition and health were concerned it was estimated that about 20 per cent. of the treated cows lost weight and that this loss was relatively greater in heifers and smaller cows. It was not possible to investigate the effect of treatment on heart rate in all animals under experiment, but where this was done an average increase of 10.2 beats per minute was observed in the treated animals ; the increase being more marked in the mature cows. In some isolated cases over-feeding of the iodinated casein occurred and symptoms of hyperthyroidism developed. Generally speaking treatment had no effect on the incidence of such trouble as mastitis, lameness and abortion. Nevertheless there was a significant effect on the incidence of heart abnormalities, high respiratory rates, nervousness and digestive disorders and on the presence of iodism.

The farmers on whose herds these trials were carried out were asked to express an opinion on the value of feeding iodinated protein under commercial conditions. Eighty per cent. were in favour of its use, but qualified their opinion by saying that very strict control would need to be exercised. The author himself is very guarded on this point and underlines difficulties inherent in using a material such as iodinated casein under commercial conditions.

Blaxter (*J. agric. Sci.*, 38 (1948), 1, 20) has followed these very interesting trials with further experiments in which he investigates the effects of severe experimental hyperthyroidism in sheep induced by feeding iodinated casein. He records the marked effect of hyperthyroidism on the metabolism of the sheep and apart from effects on nitrogen metabolism draws attention to the increased excretion of calcium which, it is suggested, is a direct effect of iodinated casein on osteoclastic

activity. Similarly there was an increase in phosphate excretion again arising mainly from bone. The author draws attention to the possible adverse effects that increase losses to the body of calcium, phosphorus and protein during lactation would have on the general metabolic cycle of the dairy cow, bearing in mind that a dairy cow in early lactation is often in negative balance in respect of calcium and phosphorus.

These findings serve to underline the dangers which would attend the immoderate or careless use of such potent material as iodinated casein.

R.G.B.

DAIRY BACTERIOLOGY

The 4th International Congress for Microbiology met in Copenhagen in July 1947 and the detailed report of the proceedings, which embraced many important aspects of microbiology including agriculture and dairying, will be published in the coming autumn. This volume should be read by all those interested in the specific and general aspects of agriculture and veterinary microbiology. The page references that follow are to *Abstracts of Communications to the Congress*, issued in Copenhagen, 1947.

The importance in cheesemaking, of bacteriophage—a bacterial virus destroying the host—was mentioned in the last Quarterly Review. The nodule organisms of the *Leguminosae*, which are of such great importance in determining the establishment and vigour of the plants, are also in some circumstances attacked and destroyed by bacteriophages which are specific to a greater or lesser degree. (*Observations sur le bactériophage du bacillus radicolica (Rhizobium)*, A. Demolon and A. Dunez. Page 147).

It is known that excess of molybdenum in the soil may have unpleasant effects on the stock consuming the herbage, but traces of the metal, partly replaceable by vanadium, appear to act as a specific catalyst for nitrogen fixation by the soil organism *Clostridium butyricum*. (*The effect of molybdenum on nitrogen fixation by Clostridium butyricum*. Page 151).

Many previous estimates of the numbers of micro-organisms (bacteria and fungi) in the soil have been made by indirect methods. P. C. T. Jones and Janet Mollison (page 151) have devised a direct method which—proved statistically—estimates the number of bacteria in various soils at 3,300,000,000 to 8,000,000,000 per gramme. The length of fungal mycelium in allotment soil was found by the same method of estimation to be about 393 metres. We may now compare the soil population with that of other media.

In the hilly districts of the North and West the nodule organism of clover may be “ineffective,” i.e., unable to promote normal growth of the plant in the absence of nitrogen in the soil. This ineffectivity of a nodule is due to the inability of the bacteria in it to grow normally. The failure may be due either to the strain of bacterium or to the host plant (H. G. Thornton, page 160).

Many of the organisms which have been found to produce antibiotic

substances, i.e., those which kill or inhibit other micro-organisms, are found in the soil. The successful application in medicine of the antibiotics isolated has raised the question of the association of organisms in the soil itself. It has already been found that certain plant pathogens may be controlled by the growth in the soil of other micro-organisms producing antagonistic substances, when favourable conditions for their growth, i.e., appropriate manuring, were provided. These observations obviously open up interesting possibilities. (Selman A. Waksman, page 161.)

A.T.R.M.

DAIRY HUSBANDRY

Milk production with special reference to quality payment. Cochrane, E. R. *J. Soc. Dairy Techn.*, 1 (1948), 253.

A thought-stimulating paper on the controversial subject of payment for milk on quality basis. The nutritional value, keeping quality and the safety of milk, together with factors influencing them, are discussed.

The progeny testing of dairy bulls. Braude, R. *Emp. J. exp. Agric.*, 16 (1948), 90.

Difficulties inherent in progeny testing are discussed. Four methods for a progeny test: the inheritance grid, the inheritance curves, the performance card and a tabular method are illustrated on data relating to one bull. A standard method for presenting results of a progeny test is suggested.

Effect of delay in diluting and cooling on keeping quality of bull semen. Anderson, H. W. and Seath, D. M. *J. Dairy Sci.*, 31 (1948), 550.

Results of a test with 42 ejaculates from 6 different bulls have shown that a delay in either the diluting or the start of the cooling process tended to lower the quality of the semen as measured by motility and methylene-blue reduction tests.

Reactions to hot atmosphere of Jersey cows in milk. Riek, R. F. and Lee, D. H. *J. Dairy Res.*, 15 (1948), 219.

Four Jersey cows were exposed to controlled hot atmosphere. Various combinations of dry bulb temperatures from 65° to 110°F. and of absolute humidity from 6 to 16 gr. of moisture/cu. ft. of dry air were used. The following observations were recorded: rectal temperature rose in hotter conditions and exceeded 107°F. under the hottest atmosphere. Respiratory rate rose with increase in either temperature or humidity; the highest was 200/min. Pulse rate was not affected by temperature but slightly by humidity. Changes in the behaviour of the cows were recorded. Milk yield or butter-fat content was not affected. Blood calcium and phosphate levels fell, but the erythrocyte count was unaffected.

Effect of water sprinkling with and without air movement on combing dairy cows. Seath, D. M. and Miller, G. D. *J. Dairy Sci.*, 31 (1948), 363.

Tests conducted on 6 Jersey cows in warm weather showed that when removed from sunshine, sprinkled with water and subjected to a gentle breeze, rapid changes towards normal body temperature and respiration rate occur.

A self-serving sprinkling device for cooling dairy cattle. Seath, D. M. and Miller, G. D. *J. Anim. Sci.*, 7 (1948), 251.

In a small scale experiment with Jersey cattle in Louisiana when the atmospheric temperature was about 90°F. in the shade at 11.0 a.m., the body temperature of milking cows kept in the sun was found to average 104.08°F. and when kept in the shade 101.91°F. Where an automatic water sprinkling device was fixed and used in the shade the average body temperature was further reduced to 100.76°F. Under the three treatments the average respiration rates were 113.0, 85.2 and 56.7 respectively. As the sprinkling device used only 16 lb. of water per nozzle hourly the authors point to the possibility of relieving dairy cattle by this means under conditions of high temperature.

Relative milk production of cows in pen barns and stanchion barns. Graves, R. R., Dawson, J. R. and Kopland, D. V. *U.S.D.A. Circ.* 763, Nov. 1947.

A comparison is made between the yield of cows when kept during one lactation in a normal stall type cowhouse and when kept during another lactation in a pen barn. The latter consists of a range of large loose boxes along each side of a feeding passage, each box designed to house 4 to 8 cows without tying. Although the number of cows used is small there is an indication of greater yield in the pen barn where the cows appeared to be more comfortable and suffered less from lameness. It is, however, pointed out that in the loose system of housing 15-25 lb. of straw for bedding is required per cow daily compared with 8-12 lb. in the stall type cowhouse.

Some effects of type of shelter upon dairy cattle.

Dice, J. R. *Bull. N. Dakota agric. Exp. Sta.*, 344. April, 1947

Between 1926 and 1942 the health, body weight and yield of Friesian Guernsey and Jersey cows were compared for animals kept in a cowshed with those kept in an open yard with access to a shed. Outside temperatures fell occasionally to below 32°F., whereas cowshed temperatures were seldom below 50°F. No differences between the groups in milk yield, live weight or health, apart from very occasional frozen teats and slightly more mastitis in the outdoor group, were recorded.

Dairy barn ventilation. Foss, E. W. *Ext. Bull. Maine agric. Exp. Sta.*, 277. Oct., 1947

This advisory bulletin is concerned with the ventilation of the American two-storey cow barn in which hay and straw is stored in the large upper storey. Normally, ventilation of these buildings includes the provision of a large flue from a point a few inches above the ground floor passing through the hay loft and emerging as a chimney above the roof. Details of construction of this out-take flue and also of in-take flues are given.

Care and management of dairy cows. Dawson, J. R. and Underwood, P. C. *U.S.D.A. Farmers Bull.*, 1470, Jan. 1947.

This comprehensive little bulletin, first issued in 1926 and revised last year, gives a mass of information on herd management most of which would be useful to the novice and some of which would be helpful to the young dairy farmer and student. Although an American publication, much of the advice is applicable in Britain.

Experiments in Milking Technique. Dodd, F. H. and Foot, A. S.

1. **Effect of washing the udder with hot water.**
2. **Effect of reducing milking time.**

J. Dairy Res., 15 (1947), 1.

Using 9 cows in an experiment lasting 9 weeks, a comparison was made between udder washing with cold water at least 20 min. prior to machine milking and washing with hot water (115—120°F.) within a minute of milking. No significant changes were found in yield or quality of milk and no major changes in rate of milking were observed.

An attempt was made in an eleven week experiment, using 6 cows, to increase rate of milking by an enforced reduction in duration of milking. The duration of milking for each cow was gradually decreased to 60 per cent. of the normal milking time ; thus the teat cups were frequently removed before milking was complete. This experimental treatment produced only minor changes in rate of milking, the yield of milk was slightly depressed and the quality remained unchanged.

It is concluded that it is impractical to attempt to milk all cows to a preconceived time limit which bears no relation to their respective inherent milking speeds.

The effect of preparation of the cow on the rate of milking. Vearl Smith and Petersen, W. E. *J. Dairy Sci.*, 31 (1948), 588.

Using 5 cows conditioned to the routine of washing with hot water (120-130°F.) two minutes prior to milking and to the use of the strip cup immediately before milking started, speed of milking records were obtained. These records are compared with the records obtained when no washing or stimulation to "let-down" was given to the same cows. They show that when no stimulation is given the delivery of milk is delayed by 30 to 60 sec. though once the "let-down" has taken place the rate of milking is normal.

A.S.F.

POULTRY HUSBANDRY

There is no doubt that, generally, improvement in breeding appears the most attractive path open to the poultry keeper who is attempting to secure a more profitable egg production. The attraction exercised by breeding problems has also had an influence on research centres, and as a result our knowledge of poultry breeding has greatly outstripped the poultry keeper's ability to keep abreast of scientific progress. In the sphere of management a much smaller gap exists, and much research work carried out recently indicates an increasing interest in methods of increasing egg production by feeding. Quite probably, this change in interest indicates a realization that increased egg production by breeding methods with flocks already laying at a high level is achieved but slowly, whereas quicker results are reached by ensuring that a bird fully expresses her capabilities by improved nutrition.

Research work on nutrition has followed two main lines. On one side, workers have attempted to determine what particular part of the food is essential; on the other, interest attaches to those attempts to secure temporary effects—mainly in carcass quality improvement—by feeding substances that intensify those effects resulting from endocrine secretions.

The first line of approach seems to have more permanent value, and useful work has been carried out on the requirements of chicks for amino acids—the constituent parts of proteins.

This work, i.e., the determination of those amino acids making up proteins which are of major value in poultry feeding, is of great importance to the poultry keeper. Ultimately, it will allow him to reduce the amount of protein—an expensive food—and still maintain high production.

The position is, however, complicated by the fact that protein foods contain not only amino acids but vitamins, which poultry need also. The effects of the amino acids and vitamins are also interrelated. An example is quoted by H. R. Bird who deals with this subject very lucidly in the *U.S.D.A. Yearbook of Agriculture*, 1943-47, *Science in Farming*, 235-238, and points out that when growing chicks consume large quantities of corn, they have increased requirements for either tryptophane (an amino acid) or nicotinic acid (a vitamin).

Bird quotes another interesting case of growing chicks having soyabean meal as the only protein supplement. This diet was effectively supplemented by an amino acid (methionine) or by two vitamins (pantothenic acid and choline). The diet mentioned could also be supplemented by a small percentage of fish meal, but this does not contain enough of the materials mentioned to account for such an effect. Bird suggests that these chemically dissimilar materials act as intermediaries in metabolism rather than constituents of body tissues, and puts this forward as the explanation of their ability to substitute for one another.

Investigation into the nature and effect of amino acids has now allowed the nutritional chemist to recommend the requisite quantities of a number of amino acids which have been found necessary for growing chicks, i.e., glycine, methionine, cystine, lysine, arginine and tryptophane.

No doubt further progress will assist poultry keepers to make up foods with a maximum of efficiency and the minimum of expense.

Another interesting point dealt with in Bird's article is the use of cow manure as a source of vitamins for chickens. It is pointed out that bacteria in the rumen of the cow can synthesize certain vitamins, and with poultry the addition of cow manure to a low grade diet decreased egg production but increased hatchability. Drying the cow manure at 80°C. destroyed the factor that decreased egg production, but did not destroy the factor that improved the growth of chickens and increased hatchability. The same factor is also found in the droppings of mature chickens, and no doubt explains the better than anticipated hatching results obtained with barn-yard fowls in the past and with birds kept under intensive conditions today.

Among other interesting articles of recent months is a paper by F. B. Hutt and R. S. Gowe in *Poultry Science*, 27 (1948), 286-293, on "The Supposed effect of Iodocasein upon egg production." The authors examine the evidence put forward by other writers and compare it with the results of their own experiment. In their summary these two authoritative writers conclude that no increased egg production is obtained by feeding iodocasein. This is of interest because recently there has been a tendency to press the supposed advantages of using iodine salts as a method of increasing egg production.

A subject which, normally, receives little attention is dealt with in an article by A. L. Palafox in *Poultry Science*, 27 (1948), 277-281. This article "A Comparison of the fertility and hatchability performance of Stud and Pen mated White Leghorn pullets and cockerels" calls attention to the better fertility performance of the pen mated birds.

Among recent poultry publications is a book entitled *Modern Poultry Husbandry*, by Leonard Robinson. (Crosby Lockwood, Pp. 522). This deals extensively and in a common-sense way with the day-to-day problems of poultry keepers and is a useful and readable volume for the newcomer and for the manager of a poultry unit who wishes to extend his knowledge of the craft.

R.C.

CROPS AND PLANT BREEDING

Harvest sprouting of cereals

Wet conditions for the 1948 harvest have again focussed attention on the sprouting of cereals in the ear and lend a rather topical interest to L. Smith's report (*J. Amer. Soc. Agron.*, 40 (1948), 32-44) that the chaff (inner and outer pales) tends to inhibit the germination of the enclosed grains. In experiments with wheat, oats and naked and covered barley he showed that in Petri dishes the "shelled" caryopses gave fuller and quicker germination than those left enclosed in their chaff. If moulds developed, they tended to attack the "shelled"

caryopses. In soil it was found that shelled and unshelled grains of wheat gave about the same final germination figure, but the shelled grains germinated more quickly. The well-known resistance to sprouting in red-grained wheats as compared with white-grained shows that the chaff is not the only controlling agent at work in preventing sprouting, but Smith's observations show that the chaff must be taken into account.

Germination tests

The use of 2, 3, 5—triphenyl tetrazolium chloride for rapid estimation of germinating capacity was developed in Germany during the war. The procedure with, for example, maize, was given by Lakon (*Ber. dtsh. bot. Ges.*, 60 (1942), 434) as follows: grains are soaked in water for 18 hours, then cut lengthwise so as to divide the embryo medianly. The halves are laid in a Petri dish and a 1 per cent. solution of 2, 3, 5—triphenyl tetrazolium chloride (or 2, 3-diphenyl-5-methyl tetrazolium chloride) added so as to just cover the cut surfaces. Respiratory activity in the living tissue of the embryos then produces a red coloration, visible in 3 to 4 hours and completed in 24 hours at room temperature. Grains may be considered germinable if the whole embryo is coloured, or if the plumule, including the root initials borne on it, and half the scutellum are coloured. Satisfactory estimation of germination with a wide range of material has been reported by Porter *et al* (*Plant Physiol.*, 22 (1947), 149-159). Shuel (*Sci. Agric.*, 28 (1948), 34-38) has tried the effect of simplifying the method by omitting the pre-soaking and cutting. With wheat, oats and barley he found fair agreement between the tetrazolium estimate and germination test, although with old seed of low germination the tetrazolium method often over-estimated the germination. By performing the test at 45°C. the time required was cut down to 5 to 6 hours.

Seed storage

A series of papers under the general heading "Grain storage studies" by Milner and Geddes and latterly by Milner, Christensen and Geddes in the volumes of *Cereal Chemistry* for 1945, 1946 and 1947 have added considerably to our knowledge of the course of events during seed storage. They show that the relatively sudden increase in respiration occurring when the critical moisture content is exceeded is always associated with the growth of moulds, mainly *Aspergillus* spp. By experiments with autoclaved seed and with the fungistatic agent thiourea, they produce strong evidence that the main part of the total respiration is that of the moulds, respiration of the seed being much less. Studies of respiratory quotients provide more evidence in the same sense. Since the germination of moulds is known to be dependent on the relative humidity of the air rather than the moisture in the substrate, it is concluded that the critical moisture content is simply that which is in equilibrium with air of the minimum relative humidity for mould germination. With sound grain and normal temperatures this minimum relative humidity is about 75 per cent., but under other conditions it can vary in either direction. For example, with damaged seeds it is lower, possibly because nutrients are then more readily available to the

moulds. Under adiabatic conditions mould respiration raises the temperature to 52°-55°C. when the moulds are killed. The activity of thermophilous bacteria may then cause a further rise to 68°-70°C., but only with very high relative humidity (about 95 per cent.). Finally there may be further heating through non-biological oxidations, which would ultimately lead to combustion. These later stages occur more easily with soya beans than with wheat.

From a practical point of view, these studies are important in showing that the damage to germination and quality quickly produced by bulk storage at too high a moisture content is due to mould growth. The ordinary precautions such as spreading out the seed, turning it or shifting it from bin to bin, etc., are probably not only of value in encouraging the dissipation of heat, but also in keeping down the relative humidity in the immediate environment of the individual seeds, by dispersing water vapour. Even in the short periods (10 days) covered by many of the experiments, however, it was found that respiration of the seeds themselves could, with high moisture content, cause injury to germination and it may be that over long periods of storage, seed respiration has also to be considered.

A note by Whympster and Bradley (*Cereal Chem.*, **24** (1947), 228-9) gives an indication of how long wheat may remain viable. Stored at a moisture content of 4.3 to 4.8 per cent. in sealed tubes in 1913, the last sample withdrawn in 1945 still showed a germination of 69 per cent.

Physiology of yield in cereals

Increased yields are obviously the ultimate aim of all crop improvement work and yet the physiology of yield, because of its complexity, remains one of the most baffling problems in agricultural botany. The famous English barley breeder, Beaven, in his selection work attached great importance to the ability of a barley variety to transfer a high proportion of its foodstuffs to the grain; he used as a moment of selection his "migration coefficient" (grain/straw ratio), without, it must be admitted, fully convincing other cereal breeders that it had all the value he attributed to it. Kiesselbach, however, in a recent paper on maize (*J. Amer. Soc. Agron.*, **40** (1948), 213-36) has brought forward a body of evidence and an interpretation which appear to lend support to Beaven's ideas, though Kiesselbach himself makes no reference to Beaven. For example sweet corn pollinated by a variety with starchy endosperm produces starchy grains because the factor for starchy is dominant. Kiesselbach has shown that as a result of such out-pollination the total yield (grain and straw) is increased, and also the yields of grain and of straw, while the ratio of grain to straw increases. Since the sweet grains contain a much higher proportion of water-soluble carbohydrates, the author suggests that they are in effect less efficient storage organs than starchy grains. This is presumed to cause an accumulation of photosynthetic products in the leaves and, therefore, a decrease in the efficiency of photosynthesis. Similar experiments with waxy corn, which is intermediate in content of water-soluble carbohydrates, gave results which agreed with the same hypothesis. Further support was obtained from

experiments in which the ear shoots were removed, thus depriving the plants of their main storage organs, as well as from further experiments in which the leaf area was reduced by splitting leaves down the midrib and removing one half; this gave an apparent increase of 50 per cent. in the assimilatory efficiency of the remaining halves. Thus Kiesselbach explains the higher yield of starchy maize compared with waxy and of waxy compared with sweet in terms of the efficiency of the different types of grain as food storage organs, or as Beaven would probably have put it, in terms of their migration coefficients.

Need for caution in releasing new varieties

Two reports from the United States show the need for careful and extensive testing of the products of plant breeding before releasing them to farmers. The first, by Down (*J. Amer. Soc. Agron.*, **40** (1948), 374) refers to self-pollinated cereals, barley and oats. At Michigan Experiment Station the procedure with new strains considered worth selections, grow them as progeny rows and discard any rows which show segregation, grow them as progeny rows and discard any which show segregation. It has now been found necessary to keep the several progenies separate during the bulking up process until enough of each has been obtained to sow a drill width about 100 yd. long. This is because at the drill width stage variants have appeared which were not previously noted. It is suggested that their expression varies according to the environment and may, therefore, not be obtained in every season.

The second case, reported by Josephson and Jenkins (*J. Amer. Soc. Agron.*, **40** (1948), 267-274) is of a kind which is only likely to occur in cross-pollinated crops. Certain commercial maize hybrids, in Kentucky, Tennessee and Indiana, were found on occasions to give a very poor set of grain. This was found to be due to poor pollen production. The hybrids concerned carried a form of male sterility variable in expression, inherited *via* the cytoplasm and tracing back to two inbred lines used in breeding the hybrids. This defect in the hybrids would not be detected in small scale trials, since they would then be pollinated by other hybrids in the trial; hence the need for field scale tests of new maize hybrids before they are released.

J.L.F.

HERBAGE

The ash components of some moorland plants. Thomas, Brynmor and Trinder, N. *Emp. J. exp. Agric.*, **15** (1947), 237.

The mineral constituents of the following moorland species were determined at monthly intervals from February to September—flying bent (*Molinia caerulea*), deer-grass (*Scirpus caespitosus*), blaeberry (*Vaccinium myrtillus*), white bent (*Nardus stricta*), stool bent (*Juncus squarrosus*), draw-moss (*Eriophorum vaginatum*).

Molinia caerulea.—Calcium is relatively low but increases from 0.142 per cent. in February to 0.291 per cent. CaO in September. Phosphorus is high, 0.927 per cent. P_2O_5 in May and gradually falls to 0.274 per cent. in September. Manganese, iron, copper and cobalt are not present in larger amounts than in good lowland grass and inferior to common heather which is an exceptionally valuable source of these elements.

Scirpus caespitosus.—The composition of deer grass is very similar to that of flying bent although P_2O_5 content is slightly lower.

Vaccinium myrtillus.—The blaeberry, like other members of the *Ericaceae*, is a rich source of lime. In the leaf CaO varies between 0.978 per cent. and 1.50 per cent. and the green stem from 0.840 to 1.038 per cent. By comparison P_2O_5 is low varying from 0.366 per cent. to 0.583 per cent. in stem or leaf. As a source of Mn, Fe and Cu, blaeberry is one of the best of the moorland plants, being comparable with heather. The amount of cobalt present is comparable with that found in the other species examined, but is lower than that of heather.

Nardus stricta.—No other species examined was poorer than *Nardus* in Ca and Cu content, but the cobalt content was similar to that of other moorland plants.

Juncus squarrosus.—The calcium content was as poor as that of *Nardus*. Fe and Cu are present in relatively large amounts; Co content is about the average for moorland species and Mn is low.

Eriophorum vaginatum.—The amount of lime in this plant is low, but for a moorland plant the content of phosphoric acid is high. The leaf butts or "scallions," held to be particularly nutritious, are richer in P_2O_5 than the leaf. In August the leaf butts contained 1.018 per cent. P_2O_5 and the leaf 0.491 per cent. Fe, Cu and Co are present in the leaf butts in quantities comparable to heather.

Of the above species blaeberry alone contained lime in quantities similar to heather. The remainder are poorer in lime than ordinary lowland pasture. Draw-moss, particularly the "scallions," and actively growing *Molinia*, contain amounts of phosphorus similar to cultivated grasses. The blaeberry and the "scallions" of draw-moss are very good sources of iron and copper, but *Nardus* is distinctly poor in both. Draw-moss contains larger amounts of cobalt than any of the other species examined while blaeberry is not as rich or *Nardus* as poor in cobalt as had been expected. This last finding is of interest in view of the dominance of *Nardus* on swards associated with "pine" in sheep, although the samples of *Nardus* examined were not from pinning land.

Graziers believe that a mixed moor provides the best type of hill grazing, and it is suggested that the results of these analyses provide a substantial basis for this belief. Where there is a balanced mixture of species, with reasonable proportions of heather and patches of draw-moss, diseases due to mineral deficiency are less likely to occur.

T.E.W.

NUTRITION OF HORTICULTURAL CROPS

Whiptail in Cauliflower

When cauliflowers are grown on acid soils failures are frequently

encountered. The two main factors that have to be distinguished in the plant are the symptoms due to manganese excess and those due to a deficiency of molybdenum. In practice both problems appear to be rectified by appropriate applications of lime. The following four abstracts indicate the recent advances in the study of this problem.

The production of molybdenum deficiency in plants in sand culture with special reference to tomato and brassica crops.

Hewitt, E. J., Jones, E. W. *J. Pomol.*, **23** (1947), 254.

Using a special technique involving pyrex containers, purified sand and nutrient reagents, symptoms of molybdenum deficiency in cauliflower have been produced and recorded photographically. The symptoms in the young plants commenced as a pale yellow-green mottling on the older leaves and the foliage developed a "water-soaked" appearance. At ten weeks, the plants had foliage in which the development of the lamina was suppressed. Younger leaves developed without any lamina and showed the symptoms characteristic of "whiptail" in the field. Finally the growing points died and short stumps of petioles were left. An analysis of the leaf tissues shows an accumulation of nitrates, and it is suggested that a shortage of molybdenum interferes with nitrogen metabolism. In order to gain further proof that the symptoms produced were those of molybdenum deficiency the leaves were painted or injected with solutions of molybdenum. The leaves made a rapid recovery thus verifying the results of the work.

A case of molybdenum deficiency in New Zealand. Davies, E. B. *Nature*, **156** (1945), 392-393.

When cauliflowers, var. *Southern Cross*, are grown on an acid loam (pH 4.7) an intervenal chlorosis develops followed by an involution of the leaf edges and marginal necrosis. In a glasshouse experiment using this soil, applications were given of different combinations of manganese, boron, copper, zinc and molybdenum with and without lime. Only those plants receiving treatments containing molybdenum were free from chlorosis. The symptoms were more pronounced where lime was omitted. In a field experiment the use of 3 lb. of sodium molybdate per acre reduced the number of "whiptail" cauliflowers.

Molybdenum in relation to Whiptail of cauliflower. Waring, E. J., Shirlow, N. S., Wilson, R. D. *J. Aust. Inst. Agric. Sci.*, **13** (1947), 187.

The whiptail disease of cauliflower occurs in New South Wales on acid soils and causes serious losses. An experiment was designed to study the effects of applying (a) sulphur, and (b) dolomite (calcium magnesium carbonate) in conjunction with different rates of sodium molybdate. At the completion of the experiment, plots receiving sulphur had a pH of 6.1, control plots 6.8, and those receiving dolomite a pH of 7.2 and over. Severe whiptail occurred only in the plots treated with sulphur alone. The application of 1 lb. sodium molybdate to the sulphur plots, reduced the incidence of whiptail. No trace of

whiptail occurred on the plots which had received dolomite or sodium molybdate at the rate of 1 lb. per acre. The authors conclude from this work that the availability of molybdenum decreases as soil acidity increases.

W.P.

FRUIT

Growth and Cropping of Apple Trees on Malling Rootstocks on Five Soil Series. Rogers, W. S., *J. Pomol.*, 22 (1946), 209-225.

The fruit soils surveys carried out in various parts of the country have made it possible to guide the prospective fruit grower in his choice of suitable soil, but they suffered from the lack of comparable trees on known rootstocks growing on the different soil types. Some rootstocks are known to succeed better than others on certain soils, but complete information for even the main soil types is still lacking. With the object of getting such information similar sets of 100 trees of *Cox's Orange Pippin* and *Worcester Pearmain* on M.I, II, VII and IX and *Cox's Orange Pippin* on M.XVI were planted on five soil series on commercial farms in Kent, viz., (A) Wye Series (Brickearth, loam), (B) Rattle Series (Clay with flints, clay loam over clay), (C) Lamberhurst Series (Wadhurst clay, silt loam over clay), (D) Curtisden Series (Tunbridge Wells sand, very fine sandy loam, of compact structure) and (E) Ladham Series (Brickearth of High Weald, very fine sandy loam of loose structure). All these plots were planted with maidens in the winter of 1935-36, with the exception of (E), which was planted in 1937-38.

Each plot was treated so as to obtain the best commercial results. Pest and disease control was left to the grower, pruning was done by the research station and county staff, or under their direct supervision, and 3 cwt. per acre sulphate of potash was given each year up to 1940 to ensure that shortage of potash would not limit growth. The cultural and manurial treatment was uniform on all plots until 1942 when it was decided to sow down plot C to check excessive growth, using a mixture of perennial ryegrass and broad red clover. Later, in 1943, plot E required similar treatment, the mixture in this case consisting of broad red clover, wild white clover and New Zealand white clover, sown in the spring.

The trees were grown as open centre bushes and from the third year onwards they were pruned on the "renewal" system, the degree of pruning being adjusted to the growth of each stock and variety on each soil type.

Vegetative vigour was measured by the length of new shoots, the number of prunings and the girth of the trunk at 9 inches above the union between stock and scion. Cropping was measured by counting the apples on each tree shortly before picking time. Other records included numbers of cankers, taken each year, and leaf scorchs in 1939 and 1942.

ABSTRACTS : GLASSHOUSE CROPS

Differences in tree behaviour from plot to plot were very great (for instance, in ten years the total yields varied from 210 to 2,350 bushels per acre) and must be considered as influenced by the site, including wind, frost and rainfall, and the management given by the different owners as well as by the particular soil types. At ten years old the following general conclusions have been drawn.

Two of the sites, plot A and plot B, were relatively free from frost damage and as a result their total crops are greater than those of the other plots which suffered more or less in 1938, 1941, 1944 and 1945. Thus the incidence of spring frost is the most important factor influencing yields.

The good Brickearths of plots A and E are obviously producing the best trees, though the more compact soils of B, C and D are giving reasonably good results. With these latter plots canker has been very troublesome, especially on the trees on vigorous rootstocks.

Possibly the most interesting results are those concerning rootstocks. M.II and M.I are giving good results with both *Cox's Orange Pippin* and *Worcester Pearmain* on all the soils. On the whole M.II has been a little better for *Cox's Orange Pippin*, but on the heavier soils M.I has been slightly better for *Worcester Pearmain*. On plot A, Brickearth, M.XVI has made very large bush trees that have cropped well within eight years, but on the clay and compact loam soils B, C and D trees on this stock have suffered badly from canker. Trees on the very dwarfing M.IX have behaved very consistently and appear to be less affected by adverse soil conditions, canker and frost than those on the more vigorous stocks. Thus for clays and similar soils M.IX seems worth special consideration.

Contrary to popular opinion that *Worcester Pearmain* is easier to grow than *Cox's Orange Pippin* the trees of the latter were in general larger than those of the former; on the best soils they carried the heavier crops and on the other soils they bore only slightly smaller crops than those of *Worcester Pearmain*.

These plots are being carried further, and it is hoped that even more interesting results may come out of the next ten years, when the trees should be producing their full crop per acre.

H.B.S.M.

GLASSHOUSE CROPS

John Innes Horticultural Institution 37th Annual Report

This Report contains a summary of twelve years intensive research on the cultivation of glasshouse crops. The first phase, 1934-38, was devoted to soil mixtures for pot plants, and resulted in the well-known "John Innes Composts." Since that period, numerous experiments have been made by Mr. W. J. C. Lawrence and his co-workers, but there has been no indication that the compost formulæ need changing. Growers are still not sufficiently aware of the importance of standardizing the soil ingredients of the composts, as only standard materials can

produce consistent results. Whereas the standards for peat and sand are easily defined, loam is a more difficult subject. If good loam is used, the formulæ of the John Innes composts are correct. In many cases, however, growers are forced to use inferior loams, characterised by deficiency in calcium and phosphate. These deficiencies should be made up when the loam is stacked, and not at the time of mixing the compost. Peat and sand can be bought as standard products, but loam, when necessary, must be standardised in the stack.

Preliminary results of investigations into the best sequence of composts for raising plants, particularly decorative subjects, are described. The plants mentioned are tomato, cucumber, lettuce, cauliflower, cyclamen, primula, and asparagus for foliage.

The second phase began in 1943 and is concerned with the effects and relative importance of different "methods" or "factors" in cultivation under glass. This phase was the logical sequence to the first, in that it became possible only by first devising composts which gave uniform plant growth. Of the twelve different "methods" investigated, of greatest importance, in order, are the compost itself, potting off, pricking off, potting on, pot size and feeding. Of only moderate importance were watering in and firming the soil. Of little or no importance were cold soil, cold water, spacing, bench colour.

The most striking point from these experiments is the great importance of the compost. If the compost is right, many common troubles disappear, the plant's toleration of environmental conditions is increased, and new methods of cultivation become possible. The improvement in growth resulting from the use of the right compost was shown in an experiment in which fifteen commercial growers from Surrey, Middlesex, and Buckinghamshire were invited to send in composts which they intended to use for raising tomatoes. The fifteen mixtures, which were very variable, were tested against John Innes composts, and only one proved to be as good as the John Innes seed compost. The implication from these tests was that the majority of commercially raised plants suffer from undernourishment in particular and from the use of poor composts in general. Modern methods could bring about radical reductions in the cost of plant production in terms of labour, time, and materials.

The third phase grew out of the need for obtaining scientific information in the design of glasshouses to be erected at the Institution's new site near Hertford, especially in relation to securing the best natural illumination.

Biological experiments in conjunction with physical computations have shown that :

(i) The loss of outside light inside the average standard commercial glasshouse in summer or winter is about 50 per cent. This loss could be reduced to about 30 per cent. by improving the design of glasshouses.

(ii) Light intensity is (in Britain) the major limiting factor in plant propagation and growth during the period October to March inclusive. Good growing cannot compensate for the avoidable loss of light.

(iii) The glasshouse running north-south is most efficiently illuminated in the period April to September, and least efficiently in the more important period between October and March.

ABSTRACTS : FLOWER GROWING

(iv) Compared with the north-south house, one running east-west is considerably better illuminated between October and March and only a little worse in the summer period, April to September.

(v) It seems that wider use should be made of glasshouses running east-west, especially for plant propagation.

(vi) Roof angle is unimportant in houses running north-south.

(vii) Larger panes of glass should be used, 24 in. wide being the minimum dimension.

(viii) A substantial saving in fuel costs can be achieved by using east-west houses.

As the second phase in these experiments was dependent on the first, so, too, the completion of the third phase is dependent on the second. The precise evaluation of natural illumination under glass requires standardisation of cultivation techniques. It is hoped that the working out and integration of all three phases will be possible in the new glass-houses to be erected at Bayfordbury.

E.S.

FLOWER GROWING

Chrysanthemums grown in Vermiculite for a Spring Crop. Stuart, Neil W. *Florist's Review*, June 8, 1948.

Experiments at the Plant Industry Station, Beltsville, Ind., have shown that the normal blooming season of a single planting of glass-house chrysanthemums can be extended for three or four months by giving short periods of artificial light during the middle of the night (*Flor. Rev.*, 92 (1943), April 15, 13-16). In the experiments outlined in this paper, chrysanthemums were grown in Vermiculite with nutrient solution and given various kinds and periods of supplementary illumination to endeavour to obtain satisfactory flower crops in the late spring and early summer.

The most successful treatment was to root cuttings of mid-season varieties at the beginning of January, pot in early February, stop at six to eight inches and grow with not more than three stems (for non-disbudded flowers). The plants were given light from 60-watt bulbs in 12-inch reflectors, spaced four feet apart and three feet above the plants, from midnight to 2 a.m. When the plants were about 15-18 inches high, lighting was discontinued and the plants were shaded with covers of black sateen from 5 p.m. to 7 a.m. each day until the buds showed colour. A night temperature of 58-60° F. was maintained during bud formation. Good flowers were obtained in late May and early June.

Plant Propagation under Fluorescent Lamps. Stoutemyer, V. T. and Close, A. W. *Bur. Plant Industry, Soils and Agric. Eng. U.S.D.A.*, 1946 (Unnumbered papers).

Excellent results in rooting cuttings were obtained in a closed, darkened propagating case, six feet by three feet, with light provided by one or two 40-watt fluorescent lamps. Bottom heat was provided by an electric heater in a false bottom. A temperature of 70° F. was found most

favourable for soft cuttings, lower for dormant ones. Vermiculite was used as the rooting medium.

For seedling growth in the same cases, Vermiculite or sphagnum moss was used, a dilute nutrient solution being supplied if the seedlings were not immediately pricked off. Higher light intensities were necessary for seedlings.

Further tests on Handling Lily Bulbs Grown in Northwest.
Stuart, Neil W. *Florist's Review*, Oct. 9, 1947.

This paper describes experiments carried out on Easter Lily (*Lilium longiflorum*) bulbs to determine the effect of storage conditions on forcing quality. Two kinds of tests were made : dipping the bulbs in fungicide and packing in wet peat to preserve live roots during storage, and various temperature treatments during storage and after potting. The author reaches the following conclusions. The value of maintaining live roots during storage is questionable. Potting and storing at 50° F. before forcing results in earlier flowers, with more buds, than storing for the same length of time in peat. A period of cool storage (3-4 weeks at 35° F.) before potting results in considerably earlier blooming when the bulbs are forced.

Les Maladies à Virus du Dahlia (Virus diseases of the dahlia).
Limasset, P. *Rev. hort., Paris*, 118 (1946), 11-14.

Apart from a description of the chief virus diseases liable to affect dahlias, the interesting points are that the peach aphid (*Myzus persicae*) is the vector of dahlia mosaic, while spotted wilt may be transmitted by *Thrips spp.*

R.H.S.

MYCOLOGY

Potato Blight (*Phytophthora infestans*)

Large ⁽³⁾ has investigated the relative efficiency of various copper fungicides in the control of potato blight in the field. With the addition of bentonite, to improve adhesion, both cuprous oxide and copper oxychloride preparations nearly equalled Bordeaux mixture in efficiency. Without the bentonite they were only as efficient as Bordeaux mixture containing half the amount of copper. The effect of spraying on yield was also studied. In later work Large and his co-workers ^(4, 5) studied the retention of the spray on potato leaves and the use of fungicides containing low amounts of copper.

In his investigation Large used a method proposed by a Sub-Committee of the Plant Pathology Committee of the British Mycological Society for determining the amount of blight on potato foliage. This method, which has been found useful by a number of observers, has now been finally revised ⁽¹⁾.

The timing of copper spraying against potato blight is of considerable practical importance. In order to give a date on which spraying should start, it is essential to be able to forecast the first probable occurrence of the disease. Beaumont ⁽²⁾ has modified the rules laid down by Dutch

workers and has devised a single temperature humidity rule. He regards as a necessary precursor of an attack of blight in Devon and West Cornwall a critical period in which (a) the minimum temperature is not less than 50° F., and (b) the relative humidity is over 75 per cent. for two consecutive days. This gave good results in most years from 1929 to 1939 except 1931. Excluding this season and considering only July and August weather records, blight followed the first critical period within fifteen days in four years, within twenty-two days in seven out of ten. In the other three seasons there was no critical period but the blight epidemic was very slight.

The importance of the destruction of potato haulm by means of chemicals in controlling blight is now generally recognized, but some growers object to the use of sulphuric acid. Wilson, Boyd, Mitchell and Greaves (7) have investigated the use of alternative non-corrosive sprays with special reference to tar acid compounds. A summary of this work giving the main practical developments has been published by Wilson and Boyd (6). They suggest that sodium chlorate, which is cheap, may be useful at the end of the season, but not on vigorous haulm. Where an effective kill of vigorous haulm is required they recommend tar acids, though these are much more expensive.

(1) **The measurement of potato blight.** Anon. *Trans. Brit. mycol. Soc.*, **31**, 140-1.

(2) **The dependence of the weather on the dates of outbreak of potato blight epidemics.** Beaumont, A. *Trans. Brit. mycol. Soc.*, **31** (1947), 45-53.

(3) **Field trials of copper fungicides for the control of potato blight. I. Foliage protection and yield.** Large, E. C. *Ann. appl. Biol.*, **32** (1945), 319-329.

(4) **Field trials of copper fungicides for the control of potato blight. II. Spray retention.** Large, E. C., Beer, W. J., and Patterson, J. B. E. *Ann. appl. Biol.*, **33** (1946), 54.

(5) **Field trials of copper fungicides for the control of potato blight. III. Low-copper fungicides.** Large, E. C. and Beer, W. J. *Ann. appl. Biol.*, **33** (1946), 406.

(6) **Potato haulm destruction.** Wilson and Boyd. *Agriculture*, **54** (1947), 201-5.

(7) **Potato haulm destruction with particular reference to tar acid compounds.** Wilson, Boyd, Marshall and Greaves. *Ann. appl. Biol.*, **34** (1947), 1-33.

Dry Rot (*Fusarium caeruleum*)

Considerable information has been obtained about this disease and its control in recent years. Foister and Wilson (2) have shown that it was largely prevented if seed potatoes were dipped in a solution of organo-mercury compounds provided the treatment was carried out immediately after lifting and that the tubers were then stored in boxes. Less control of the disease was obtained if the tubers were first clamped and then treated when removed from the clamps and riddled.

There are a number of objections to the wet treatment and Foister, Wilson and Boyd (3) have investigated the use of dusts. In preliminary

experiments they obtained a good control of the disease with a dust containing thymol as the active ingredient, but this material was liable to damage the tubers. Boyd ⁽¹⁾ has given an account of later experiments with the dry dust method.

In the same paper Boyd ⁽¹⁾ reviewed the results obtained by himself and co-workers in their investigation of the factors influencing the development of dry rot. They found that damage to the tubers by riddling was one of the most important factors leading to development of the disease. Injury at lifting was often relatively unimportant, but rough handling of potatoes bagged after riddling in some cases doubled the number of infected tubers. Storing tubers in boxes instead of clamps reduced the amount of disease.

Small ^(4, 5) has also shown the importance of injury to the tubers on the subsequent development of dry rot. He found that carefully handled tubers developed little disease either in clamps or after they were taken out; heavy losses were experienced if the tubers were severely bruised either before or after clamping. He also obtained a reduction in the amount of dry rot by using the organo-mercury dip treatment. Small ⁽⁶⁾ has also described the effect of planting infected or contaminated tubers in plant establishment in the field. He found that healthy whole sets give a good plant while obviously infected sets produced a gappy plant. Healthy tubers cut with a contaminated knife gave few gaps in 1943 but many in 1944 and 1945.

⁽¹⁾ **Some recent results of potato dry rot research.** Boyd, A. E. W. *Proceedings of the Association of Applied Biologists, Ann. appl. Biol.*, **34** (1947), 634-6.

⁽²⁾ **Dry rot in seed potatoes. A summary of some recent experiments.** Foister, C. E. and Wilson, A. R. *Agriculture*, **50** (1943), 300-303.

⁽³⁾ **Control of dry rot of seed potatoes by dusting.** Foister, C. E., Wilson, A. R. and Boyd, A. E. W. *Nature*, **156** (1945), 394.

⁽⁴⁾ **The effect of disinfecting and bruising seed potatoes on the incidence of dry rot.** Small, T. *Ann. appl. Biol.*, **32** (1945), 310.

⁽⁵⁾ **Further studies on the effect of disinfecting and bruising seed potatoes on the incidence of dry rot.** Small, T. *Ann. appl. Biol.*, **33** (1946), 211-19.

⁽⁶⁾ **Dry rot of potatoes (*Fusarium caeruleum* (Lib.) Sacc.). Effect of planting infected and contaminated seed on plant establishment.** Small, T. *Ann. appl. Biol.*, **33** (1946), 219-221.

H.E.C.

ENTOMOLOGY

Investigations on the Control of the Fruit Tree Red Spider (*Metatetranychus ulmi* Koch) during the Dormant Season. Austin, M. D. and Masee, A. M. *J. Pomol.*, **23** (1947), 254.

An account is given of the results of a three-year investigation into the control of the winter eggs of this pest on apple by means of petroleum and DNC washes applied in January, February, and March.

An ingenious method of recording the mite population on the leaves of the trees is described ; it consists of laying the leaves between sheets of smooth absorbent paper which are then passed through a small household wringer. The eggs and mites are crushed and leave a record in the form of small pinkish spots when eggs are squashed, larger and darker markings being made by the mites themselves. Records can be kept in this way for some time and examined in detail when convenient.

It is shown that both petroleum and DNC washes give high kills of the winter eggs, no significant difference being noted between these two washes ; the mid-February and March applications, however, gave significantly greater egg-hatch reductions than the applications made in January. It is pointed out that even when a control of 97 per cent. of the winter eggs was achieved, the subsequent build-up of the mite population could still be serious. The writers consider that both winter and summer spraying are essential in order to achieve commercial control of this pest.

Field Observations on the Bean Seed Fly (Seed Corn Maggot)
(*Chortophila cilicrura*, Rond and *C. trichodactyla*, Rond).
Miles, M. *Bull. ent. Res.*, 38 (1948), 559-574.

Two species of fly are involved in the damage previously attributed to Bean Seed Fly. The maggots of these flies feed on beans, peas, cabbages, kale, cauliflowers, leeks, onions, cucumbers and lettuce.

The flies are on the wing from March to October, there being three or four generations a year. There appears to be no direct association between the flies and decaying vegetation. Infestation occurs mainly in market garden land that has been cultivated during periods when the flies are active ; absence of weeds and conservation of moisture are favourable to oviposition and the subsequent life of the maggots until they are able to reach food.

Field experiments are described and control measures in general are discussed. Since eggs are not always laid near the food plants and the soil may be infested before the plants are set out, dusting with calomel around the newly set out plants is, usually, not effective. Seed beds should be prepared in March. The marking of rows before setting out plants should be carried out so that only the dry surface tilth is disturbed ; harrowing should be delayed until seed crops are through the ground.

The Development of a Helicopter Spraying Machine. Ripper, W. E. and Tudor, P. *Bull. ent. Res.*, 39 (1948), 1.

An interesting account is given of experiments carried out to explore the possibilities of the helicopter for the application of sprays to ground crops. In particular the experiments were designed to study the crop interference with the spray laden slip-stream of the helicopter ; slow speeds of from 6-8 m.p.h. were found to be best, and in order to attain maximum coverage of the plants, the spray bars must not be over 6 feet above ground level. Winds higher than 12 m.p.h. reduce the uniformity of cover. The article is well illustrated and should be of special interest to those who had flying experience during the war.

A Home-made Dusting Machine for Ridge and Row-crop Work.
Staniland, L. N. and Mayor, J. *Agriculture*, 55 (1948), 203.

The machine is of a type which can easily and cheaply be made by any grower or farmer and can be used to dust over ridges or plants which do not exceed a height of 11 inches. The machine consists of a rectangular framework ; at the forward end is a central area where a single square " wheel " is mounted ; the machine runs on the square " wheel " and the rear ends of the sides of the rectangle. The bumping action of the revolving square " wheel " shakes the dust from two adjustable hessian hoppers, one each side of the square wheel. The dust hoppers are slightly longer than the side of the square " wheel " and the result therefore is two continuous lines of dust.

L.N.S.

VIROLOGY

Potatoes

It has long been known that of the two common potato viruses, X and Y, the former occurs in many strains of differing virulence, varying from one causing severe necrosis to one causing practically no symptoms. Although more than one strain of potato virus Y has been described, it has generally been assumed that this virus, as it occurred in the field, did not vary much in virulence. However, recent work ⁽¹⁾ has shown that strains of virus Y, causing very different diseases, do occur, and the symptoms of infection may vary from acute leaf-drop streak to a faint veinal mosaic. It is suggested that breeding for resistance to virus Y might be worth while. The American variety, *Katahdin*, is much more difficult to infect than any other variety and the combination of resistance and intolerance appears to be worth seeking.

Some experiments to test the resistance of potato varieties to virus Y have been carried out in America ⁽²⁾. It was found that the varieties and seedlings tested could be grouped as (a) highly resistant, i.e., seldom contracting more than a trace of infection in the field, (b) moderately resistant, showing 10-20 per cent. infection by plant counts, (c) slightly resistant with up to 100 per cent. infection, (d) non-resistant, contracting virtually 100 per cent. infection. The extent to which varieties exhibited resistance depended on the dosage of the aphid vector, *M. persicae* ; varieties apparently resistant in the field were not necessarily resistant under heavy aphid infestation in cloth cages.

In testing for the presence of leaf roll it is the custom to use young healthy potato plants as indicators and this involves the maintenance of stocks of virus-free seed potatoes. A test plant easily grown from seed which is susceptible to the leaf roll virus and also acceptable to the aphid vector, would be very welcome ; such a plant is suggested in *Physalis angulata* which seems to fill these requirements ⁽³⁾.

Sugar Beet

Some studies on the factors affecting the loss of sugar beet caused by beet yellows virus ⁽⁴⁾ have been carried out and the effect of the virus on the yield of sugar beet was tested in relation to various manurial treat-

ments. When plants of the *Kleinwanzleben E* variety were colonized with infective aphides, it was observed that plants on very fertile sites suffered much greater losses than on those of low fertility. No evidence was found that fertilizers and manures decrease the incidence of virus infection, with the possible exception of phosphate. Potash and agricultural salt tended to increase yellowing and ammonium sulphate leaf necrosis; leaf reddening was reduced by phosphate and potash. Most fertilizers have little effect in determining the spread; it was found that salt gives a small but constant reduction but it also reduces the yields of infected plants.

At present there seems little sign of resistant types or varieties of sugar beets from which immune or resistant beets could be bred. Seed-transmission of plant viruses is on the whole a rare phenomenon and this is certainly fortunate because seed-transmission increases the difficulties of control. It is of interest, therefore, to read a note in *Nature* ⁽⁵⁾ recording the apparent transmission of a disease resembling virus yellows through the seed of a particular strain of sugar beet. As a general rule, however, this virus is not seed-borne.

Brassica Crops

Virus diseases of Brassica crops are increasing in importance, both in this country and abroad, and trials have been carried out in the State of Washington, U.S.A. ⁽⁶⁾ to compare relative susceptibilities of different cabbage varieties to mixtures of the common Brassica mosaic virus diseases (Cabbage Black Ringspot and Cauliflower Mosaic). Similar trials are badly needed in this country where losses from these two virus diseases are becoming very serious.

Turnip yellow mosaic virus is now known to be transmitted by many different kinds of biting insects besides the fleabeetle which is the most efficient vector in the field. The mustard beetle and its larva, the ordinary grasshopper and the common earwig are all capable of transmitting this virus. Moreover, the faeces of infective insects are intensely infectious, so no doubt, some secondary spread of the virus takes place in this way also. ⁽⁷⁾

Tomatoes

An attempt is being made in America to breed tomato plants resistant to those two ubiquitous virus diseases, Tomato Mosaic and Spotted Wilt. Several hybrids tolerant of the mosaic virus have been found and some segregates from crosses involving *L. pimpinellifolium* also showed a high degree of tolerance in inoculation tests ⁽⁸⁾. A heritable resistance adequate for the control of the New Jersey strain of tomato spotted wilt was found in two kinds of South American tomatoes, the variety, *Rey de los Tempranos*, and some lines of the variety, *Manzana*, both from Argentina ⁽⁹⁾. Whilst on the subject of the spotted wilt virus, a hint worth passing on to dahlia growers, who may have a valuable variety infected with this virus, is mentioned. It is sometimes possible to obtain virus-free plants from a diseased stock by taking tip cuttings from emerging shoots ⁽¹⁰⁾ since the virus is rather slow-moving and the tips of the shoots remain free of virus for a time; such tip cuttings may readily be rooted.

(1) **The behaviour of some naturally occurring strains of potato virus Y.** Bawden, F. C. and Kassanis, B. *Ann. appl. Biol.*, **34** (1947), 503-516.

(2) **Resistance of potato to virus Y, the cause of vein-banding mosaic.** Schultz, E. S., Stevenson, F. J. and Akeley, R. V. *Amer. Potato, J.*, **24** (1947), 413-419.

(3) ***Physalis angulata*, a test plant for the potato leaf-roll virus.** Hovey, C. *Phytopath.*, **38** (1948), 505-507.

(4) **Factors affecting the loss of sugar beet caused by beet yellows virus.** Hull, R. and Watson, Marion. *J. agric. Sci.*, **37** (1947), 301-310.

(5) **Transmission of a disease resembling virus yellows through the seed of sugar beet.** Clinch, P. E. M., Loughnane, J. B. and McKay, R. *Nature, Lond.*, **161** (1948), 28-29.

(6) **Reactions of cabbage varieties to mosaic viruses.** Pound, G. S. *J. agric. Res.*, **75** (1947), 19-30.

(7) **Specific crystalline protein and nucleoprotein from a plant virus having insect vectors.** Markham, Roy, Matthews, R. E. F. and Smith, Kenneth M. *Nature, Lond.*, **162** (1948), 88-90.

(8) **Preliminary report on breeding tomatoes for resistance to tobacco mosaic virus.** Kikuta, K. and Frazier, W. A. *Proc. Amer. Soc. hort. Sci.*, **49** (1947), 256-262.

(9) **Resistance to spotted wilt in tomato.** Holmes, F. O. *Phytopath.*, **38** (1948), 467-473.

(10) **Elimination of spotted wilt from a stock of dahlia.** Holmes, F. O. *Abstr. in Phytopath.*, **38** (1948), 314.

K.M.S.

INSECTICIDES AND FUNGICIDES

Application of Insecticides and Fungicides to Field Crops

SPRAYING. Is it really necessary to use 100 gallons of water to apply 1 gallon of lime sulphur? Cannot methods be devised needing less labour than conventional spraying? Such questions are frequent nowadays but the answers require some attention to basic principles. The object is a uniform and controlled distribution of the insecticide and fungicide over the growing plant; uniform—because most pest control chemicals will damage the plant if over-applied; controlled—because an indiscriminate and wholesale dispersal of a poison is not in the best interests of public health. Both objects are achieved in conventional spraying by using water as the carrier. The amount retained on the sprayed foliage is thereby automatically controlled by the interfacial tensions; the excess spray will run off, making it impossible to over-spray. Proposals that have been made from time to time to use unstable emulsions or so-called oil-flocculated suspensions (Fajans, E. and Martin, H., *J. Pomol.*, **16** (1938), 14), which by a preferential retention of the non-water phase reduce loss in the “run-off,” have failed in practice because this safety factor is lost. Control over the distribution of the spray is obtained by a suitable choice of spray nozzle and pressure.

With modern equipment such as described by Kearns (*Rep. agric. hort. Res. Stat. Bristol* (1945), 110) accurate placement of the spray is possible in wind up to 10 m.p.h. Spraying in stronger breezes is avoided because much of the spray becomes uncontrollable and spray drift may, by alighting on previously sprayed and dried foliage, increase deposit beyond safe limits.

To reduce the labour involved in fruit-tree spraying with manually-operated spray brooms, the feasibility of using a spray broom fixed to the machine is being examined. This method has long been used for potato and hop spraying and preliminary results have shown a marked reduction of man-hours needed in fruit-tree spraying. But little data are yet available on the biological efficiency of the method and Kearns has suggested (*The Fruit-grower*, Dec. 4, 1947) that a replanning of the plantation to a system in which the trees are planted as hedges may be necessary for the full efficiency of "automatic" spraying.

DUSTING. Practical experience in dusts, long used in place of sprays where water is scarce or the terrain is unsuitable for heavy machinery, has shown these much less effective than sprays. The poor results are mainly due to the poor retention of the dust on treated foliage and, to remedy this fault, trials are reported (e.g., Tukey, H. B., *Amer. Fruit Grower*, 67 (1947), 8, 16, 43, 53) of various "liquidusters" in which oil droplets are added to the dust stream. No outstanding success is claimed. Staniland and Mayor (*Agriculture*, 54, (1948), 518) have described a simple appliance for the dusting of seedling crops.

ATOMIZATION. During the war various appliances were devised for producing fog screens from crude petroleum oil; tests of these machines, e.g., the Besler and the Todd (TIFA) generators, for the production of insecticidal fogs soon followed. For screening purposes the best droplet size is $\frac{1}{2}$ to 1 micron but droplets so small fail to settle and seem not to make contact with surfaces which they approach. Consequently, modifications to secure large droplets are necessary but so far no successful method of avoiding extensive loss of material in drift has been devised.

Similar difficulties arise in application from aeroplanes and helicopters; the unexpected damage to crop plants some 5-10 miles from the site where 2:4-dichlorophenoxyacetic acid was applied by plane for weed control, was serious enough to cause official discussions in the United States (*Agric. Chemicals*, 3 (1948), 41) with the object of prohibiting the use of the chemical for aerial application. The down-draught of the helicopter rotor should permit a more controllable application but Ripper and Tudor (*Bull. ent. Res.*, 39 (1948), 1) found that, for best results, the machine should fly with spray bars not more than 6 feet above the ground.

H.M.

SOILS

The use of Salt for Sugar Beet. Crowther, E. M. *British Sug. Beet Rev.*, 16 (1947), 19-22.

In a review of the results of 152 fertilizer trials carried out on commercial farms during the period 1940-46, the author concludes that for sugar beet and mangolds, sodium acts as a true plant food ; it does not act by making potassium more available, nor does it exhaust the potassium reserves in the soil. Agricultural salt should therefore be regarded as a straight fertilizer supplying sodium, whilst nitrate of soda, for instance, is a compound supplying both sodium and nitrogen.

When used on mineral soils (i.e., all soils except fens), salt at 5 cwt./acre gave 5.1 cwt. extra sugar in the absence of fertilizer potash, whilst muriate of potash at 2 cwt./acre gave 2.8 cwt. extra sugar in the absence of salt. Muriate and salt together, both at 5 cwt./acre gave 5.8 cwt. extra sugar. At ruling prices, 5 cwt. salt gave a profit of 540 per cent., and 2 cwt. muriate a profit of 180 per cent.

The effects of 5 cwt. salt were fairly consistent, year by year, ranging from 4.4 cwt. extra sugar in 1943 to 6.4 cwt. in 1944. The effects were also fairly independent of the texture of the mineral soils, being 4.7 cwt. extra sugar on heavy soils and 5.6 cwt. on fine sands.

The response to salt of beet crops grown on fen soils is much less than those shown in mineral soils. Only 1.9 cwt. extra sugar is produced by 5 cwt. salt, or by 2 cwt. muriate.

Because salt, when applied a few days before sowing the crop, seems to affect seed germination, it is customary to recommend its application two or three weeks before the beet is sown, but there is no evidence that the slight check to germination affects final yields. On the other hand, there is little loss of effect if the salt is applied in winter, 4 months before sowing the beet. It is immaterial whether the salt is ploughed in or left on the surface.

These trials afforded some opportunity of examining the effects of salt on the tilth of heavy soils—some "capping" being observed in many centres, though the effects were very temporary and the final crop was unaffected. A long-term experiment at Rothamsted on a beet-barley rotation, which has now continued for several seasons, has shown that heavy annual applications of salt do not affect soil structure.

H.T.J.

M.D.

Lime in Relation to Availability of Plant Nutrients. Emil Truog. *Soil Sci.*, 65 (1948), 1-7.

Lime is added to soils to improve their physical condition, to neutralize acidity and to supply calcium and magnesium as nutrients for plants. Because of the effect on soil reaction lime influences the availability of plant nutrients.

A chart illustrating the effect on availability of eleven plant nutrients with changing soil reaction (pH) is given. The chart does not necessarily indicate where deficiencies arise because of the different requirements of particular plants for any individual nutrient.

ABSTRACTS : MACHINERY

NITROGEN. To maintain a satisfactory supply of available nitrogen the pH range of 6 to 8 is most favourable. Ammonification is not retarded by a moderate degree of acidity owing to the neutralizing effect of the ammonia produced. Nitrification, however, is markedly retarded by soil acidity because of inhibition of nitrifying bacteria.

PHOSPHORUS. The most favourable soil reaction for phosphate availability is between 6.5 and 7.5. At this stage there is sufficient calcium bicarbonate in soil solution to cause the formation of acid calcium phosphate, a compound in which phosphate is most readily available to plants.

Below pH 6.5, the formation of acid calcium phosphate decreases and increasing amounts of basic ferric phosphate, unavailable for plant nutrition, are produced. Also, as acidity increases, small amounts of iron dissolve in the soil solution. This reacts to form ferric phosphate.

Above pH 7.5 phosphates tend to become less available. The condition does not become serious until 3 per cent. and over of free calcium carbonate exists in the soil.

POTASSIUM, CALCIUM AND MAGNESIUM. With increasing acidity, the amounts of potassium, calcium and magnesium existing in readily available forms decrease and these elements are tightly held by excess exchange acids against solution and plant nutrition. In certain soils liming transforms fixed potassium to a more available form.

MANGANESE. Available manganese in sands and loams low in organic matter and in peats low in total manganese is often too low for crop needs if the pH rises above 7, particularly when the soils are calcareous. Oxygen causes the formation of insoluble manganese, consequently over-aeration in the soil is a causative effect particularly when the soils are free draining.

Particulars are given regarding availability of sulphur, boron, iron, copper and zinc.

The most important point is that practically all elements mentioned have their maximum availability around pH 6.5. Consequently, for general farming, it is usually recommended that acid soils be limed to pH 6.5.

W.M.D.

J.W.B.

MACHINERY

Application of Electricity to Agriculture and Horticulture

The use of electricity in the countryside generally is steadily increasing, and the interest of country people in its varied applications has been very evident at some of the large agricultural shows of 1948. A booklet (*Electricity on the Farm*, British Electrical Development Association, Savoy Hill, London, W.C.2. Price 2/6) gives an up-to-date account of the possibilities of utilization of electricity, both about farm

buildings and in the homes of farmers and workers. Examples are given of how it can be efficiently and economically used for lighting, water supply, and for driving barn and farmyard machinery.

A chapter on crop drying gives figures for consumption and cost of electricity when using all-electric grain driers, and points out that driers specially designed for all-electric operation show a saving of some 20 per cent. on running cost compared with electrically-heated driers that were originally designed for solid-fuel operation.

In general, this booklet describes in outline the types of equipment available for such processes as water heating and sterilization, but advises the customer to consult the electricity supply authority to obtain advice on which type of equipment is best for his particular requirements.

The whole booklet is based on the assumption that electricity is now generally available for farm purposes at an overall cost of 1d. to 1½d. a unit, and tables are included showing running costs for various jobs where the overall price is 1d. a unit. Examples from the tables include milking at 30d. per cow per annum, water pumping at 2d. to 6d. per 1,000 gal. according to depth of well, and grinding with hammer mills at ½d. to 1d. per cwt. according to fineness.

There are many isolated farms where a public supply of electricity is unlikely to be available for several years to come, and in such circumstances the generation of electricity by means of small engine-driven plants may be worth consideration. Beskine ("Generating Electricity on the Farm." *Farm Mechanization*, 1 (1947), 248) discusses types and sizes of generators, engines for driving them, and how to estimate what size of plant is required. He gives examples of the costs of typical installations. Farmers are well advised by Beskine to try to employ equipment of a type that will subsequently be suitable for use with the standard voltage of the public supply. Such equipment is, however, more difficult to obtain at present than some other kinds.

Electricity and Horticulture

A paper by Cameron Brown and Golding ("The Application of Electricity to Horticulture." *Instn. of Electrical Eng'rs.*) deals with the use of electricity on commercial holdings and in private gardens.

Soil warming is now largely effected by the low-voltage transformer-fed system, and examples are given of the application of this method to the heating of hotbeds, propagating beds and benches, to cloches, and to beds and borders in glasshouses. The authors emphasize the importance of the conclusion reached in the earlier work on soil warming (*Electrical Research Assocn. Repts. W/T7 and W/T7a*) that thermostatic control is uneconomical and that a constant "dosage" method is preferable. By the dosage method soil temperature varies considerably, but this does not appear to affect growth adversely provided that the soil remains well above freezing point.

Much information that is already available on the best technique of using electrical warming for various crops is given, but the paper makes it clear that much more experimental work is needed before detailed recommendations can be made for all aspects of its application.

ABSTRACTS : MACHINERY

Electrical space heating for glasshouses is approached with caution, and the view is taken that the electrical method can only be justified in the high-grade propagating house and possibly the amateur's greenhouse. It is possible that research now in progress on the insulation of glasshouses will ultimately make electrical space heating more generally attractive.

Artificial illumination, soil sterilization, and plant and bulb sterilization by electrical methods are also discussed, and references are given to various books and papers which deal with the applications of electricity to horticulture.

The physiological principles concerned with the effects of artificial illumination on plant growth, and also the experimental work on this subject carried out by various investigators, are discussed by Brandon in "Artificial Illumination in Horticulture," *E.R.A. Tech. Rept. W/T11*. This critical résumé provides a very extensive bibliography which will interest the specialist.

Nicholas (*Agricultural Engineering*, 29 (1948), 145) discusses in optimistic manner the uses of various types of radiation in agriculture. Much research has already been carried out in the United States on the action on living things of various types of radiant energy such as gamma, X and Rontgen rays, radium emanation, ultra-violet rays, the visible light spectrum and infra-red rays, and references are given to some of this work. It is stated that nearly all bacteria and fungi may be killed or attenuated by ultra-violet energy of certain wave-lengths, but that different species vary considerably in rate of destruction. Radiation from mercury lamps has been used in brooder houses and incubators, calf-pens and isolation wards for sick animals, while the middle ultra-violet rays have been used to help produce vitamin D, and infra-red rays, owing to their deep penetrating characteristic, have been found useful for various kinds of animal therapy. The opinion is expressed that there are great possibilities in the use of infra-red rays for general heating, for grain drying and conditioning, and even for such purposes as hay "finishing." Examples are also given of how high-frequency currents stimulate the germination of seeds and result in early flowering and fruit production. The conclusion "that agricultural electronics is limited only by the skill of man in putting it to work" may well be justified at some time in the future, but can be accepted only with reservations at the present stage of development. One big objection to the use of electronics and infra-red in agriculture at present is the very high capital cost for a short seasonal operation.

C.C.

PROVINCIAL NOTES

PIONEER CROPPING IN THE HEREFORDSHIRE UPLANDS

C. KINSEY

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There are about 15,000 acres of uplands in Herefordshire, mainly at an altitude of 800 to 1,000 ft., with a small proportion running up to 1,400 ft. Soils are of two types: Old Red Sandstone—generally of medium texture and fair depth; and Silurian—usually lighter and shallower. Existing swards consist either of bracken (which when growing vigorously indicates a fair depth of soil) or of *Agrostis* with some bracken and gorse. Not infrequently there is a scattered growth of strong hawthorn and birch. Such land is seldom, in the first instance, cereal-worthy; moreover, owing to steep slopes and other upland conditions, only a portion is suitable for continuous tillage work, notwithstanding the powers of the crawler tractor. It can, however, be converted to ley. As an example of what can be done, the following figures from an upland farm in the county are given:

	1938	1946		1938	1946
Wheat and Barley ...	5	60	Cattle ...	45	87
Beet and Potatoes ...	—	23	Sheep ...	170	550
Roots and Arable Fodder	27	34			
One-year ley ...	8	—			
Long ley ...	—	166			
Permanent Grass ...	280	37			
	<hr/>	<hr/>			
	320	320			
	<hr/>	<hr/>			

PIONEER CROPS

In the reclamation of these bracken-infested uplands, pioneer crops have been found invaluable as a means of securing immediate return in the form of sheep keep, and building up fertility, effecting consolidation, and preparing the ground for either tillage crops or long leys. The following notes are based on experience with pioneer cropping of some 1,000 acres occupied by various farmers or farmed by the County Executive Committee.

Cultivations. After bush clearing, ploughing is the first operation. For any tillage crop, good ploughing is half the crop and this is especially applicable to the pioneer crop, a first-rate stand of which is the key to the build-up of soil fertility.

The time of the first ploughing on bracken lands is important, and experience has shown that the most effective kill of bracken has been obtained where ploughing is carried out during the May/June period. Instances have been noted where bracken fields ploughed during the winter/spring period resulted in the return of bracken, with its subsequent

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serious competitive effect on the pioneer crop. For this reason, too, the ploughing should effectively bury the bracken.

One-way ploughing (and many of these lands are ploughable only one way), even with the extra cost involved, has therefore much to commend it. For the initial ploughing, two types of ploughs have been used—(a) the prairie buster on the deeper soils, turning a furrow about 26 in. \times 14 in., and (b) the two- or three-furrow semi-digger type, turning a furrow about 11 in. \times 6 in. The latter type is the one more generally used on old sward that is free from obstacles; it appears to be more effective in preventing the return of bracken, and more suitable for the subsequent preparation of the seedbed.

The chief aim of subsequent cultivations is to secure a fine but well consolidated seedbed.

Liming and Manuring. Soil analyses (indicating lime requirements up to three or more tons of ground limestone per acre) and subsequent crop responses have clearly demonstrated that lime is one of the greatest needs of these uplands, especially on the Silurian formations.

The modern mechanical lime distributor has proved useful in solving the problem of lime distribution, as the work can proceed without interfering with normal farm staff activities. Ground limestone, at appropriate rates, has given excellent results, and has advantages over burnt lime in the matter of handling, etc.

The available phosphate content of these soils is low in almost every instance, and a dressing of 8 cwt. of basic slag per acre, or its equivalent, has been required.

An application of nitrogen is essential in order to obtain a maximum stand of the pioneer crop. The usual dressing used is $1\frac{1}{2}$ to 2 cwt. per acre, but reliable information as to the optimum dressing has yet to be obtained.

Soil analyses have not revealed any serious shortage of potash in these upland soils, possibly because of continuous sheep grazing for generations; heavily infested bracken lands invariably have a high potash content.

The Crop and its utilization. A mixture commonly used is 1 lb. common turnip and 5 lb. rape per acre; at this rate the turnips produce larger "roots" than a higher rate of seeding. Where the soil is not too shallow 2 or 3 lb. of Thousand Headed Kale added to the mixture has been an advantage. Normally, sowing is carried out with a "fiddle" or seed barrow from mid-June to mid-July. The yield of a good pioneer crop is about two-thirds to three-quarters of a swede crop; if the rape is a good stand, its nutritive value is about that of swedes.

If the crop is eaten off by fattening tegs, it is customary to begin folding the crop in October and continue until January. Close folding seems essential in order to avoid wastage of crop and the uneven distribution of sheep manure. One acre of a good pioneer crop will keep 100 fattening tegs for about two weeks. For folding they require 200 sq. yds. per day. Before folding begins, the tegs should have a little dry feed; during the folding, hay *ad libitum* and $\frac{1}{2}$ lb., increasing to $\frac{3}{4}$ lb., per head per day of a suitable dry feed mixture are needed. The crop is also valuable for ewe hogs intended for the breeding flock, but with these the folding should be completed earlier, i.e., by the end of December.

On the poorer and thinner soils, a similar mixture, but excluding the kale and including Italian ryegrass at the rate of 15 lb. per acre, has been used. Generally, in such instances, the crop is lighter and is eaten off by the end of November. The ryegrass recovers during the winter and provides valuable spring grazing for ewes and lambs; following another period to rest, it may be grazed again in June preparatory to sowing the second pioneer crop or direct seeding to grass.

Much information is still required on the value of different seed mixtures (including various combinations of rye, ryegrass and the cruciferous plants), and the relation of time of sowing to the time of crop utilization.

SEEDING TO LONG LEY

If a good pioneer crop is obtained the long ley mixture may be sown in June or July. Alternatively, where fertility is low, a second pioneer crop may be sown. In either event a second ploughing is inadvisable, the necessary tilth being obtained by repeated discing and other surface cultivations.

THE TAKE-ALL DISEASE OF WHEAT AND BARLEY

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Owing mainly to the research of S. D. Garrett of Rothamsted a considerable amount of knowledge has been accumulated with regard to the Take-all, or Whiteheads, disease of wheat and barley. This disease, which is summarized in Advisory Leaflet No. 304, is caused by a fungus, *Ophiobolus graminis*, that persists from one season to another on the stubbles of susceptible cereals and on the roots of certain grasses, but cannot long remain in the soil in their absence. The fungus grows out from this debris, attacks the roots of neighbouring cereal seedlings and travels along them towards the crown. When it penetrates the base of the straw early the plant dies, and this may happen in patches in the field. In this country, however, the fungus does not usually reach the crown until much later in the season, when the ears have formed. The effect is then seen in a bleaching of the ears, known as Whiteheads. In damp weather the dead ears become discoloured by secondary moulds. The most satisfactory method of diagnosis is to scrape the roots with a knife: if they appear black inside, the disease is very probably Take-all. The fungus affects wheat and barley severely, but not oats, although a distinct form of the fungus, occurring in Scotland and Wales, and more rarely in some of the western districts of England, can attack oats, wheat and barley. The roots of some grasses, especially perennial weed grasses, such as Yorkshire fog, couch and bent grass, and to a lesser extent some cultivated grasses, such as ryegrass, are attacked, but the tops of the plants do not show any noticeable symptoms.

Conditions favouring the Disease

It will be evident that Take-all is likely to be most troublesome when white-straw crops are taken too frequently in the rotation or where the

land has been allowed to become foul with susceptible weed grasses. Dry weather after harvest prevents rotting of the stubbles, while a reserve of nitrogen in the soil stimulates the fungus to grow out readily. Spread of the fungus along the roots is favoured by looseness of the soil and by an alkaline medium since the fungus is aerobic and is checked by any accumulation of CO_2 in the soil. Also disease development is favoured by unbalanced nutrition of the plant and lack of adequate nitrogen at critical periods, as when leaching of nitrogen from the soil is brought about by heavy rainfall or impeded drainage.

The Disease in the South-West Province

In 1948 Take-all began to be apparent in the South-West Province about the middle of April and became increasingly noticeable during June and July, especially after a check to the growth of the plants by dry weather. Wet weather in mid-August brought about blackening of the prematurely ripened ears.

The severity of the disease varied from district to district. Damage was most severe in areas of light calcareous soils and where wheat had been grown most intensively. The following estimates were arrived at by officers in the areas in question.

Gloucestershire. In the north and middle regions of the Cotswolds 80 per cent. of the fields were affected to some extent, while over 30 per cent. of the fields were badly affected (i.e., had about half the field affected). In the north-west Cotswolds about 60 per cent. of the fields were affected to some extent, 25 per cent. of them being a practical failure.

Somerset and Dorset. In mid-Somerset 15 per cent. of the fields were badly affected, while in west Somerset 50 per cent. were badly affected. The situation in south Somerset and Dorset seems to have been much less acute.

Wiltshire. In the Warminster area 50 per cent. infection was reported with 5 per cent. of these with considerably reduced yield. In the Pewsey area 20 per cent. of the crops were rather heavily affected.

Devon and Cornwall. G. H. Brenchley reports that in the Exeter district of Devon something like 75 per cent. of the wheat and barley was affected and in many cases the disease was responsible for a 50 per cent. reduction in yield. The disease was less common in other parts of Devon and Cornwall.

Analysis of Cases

The 1947 cropping was ascertained in 67 fairly severe cases of Take-all throughout the Province, with the following results:—

1947 Cropping					No. of cases of Take-all reported
Wheat or barley	...	...	...	...	24
Fallow after wheat or barley	...	...	...	...	22
Fallow after ley or other crop	...	...	...	...	6
Potatoes	...	...	...	...	4

In addition there were 2 cases after each of the following: oats, dredge corn, roots and 1-year-ley after wheat and barley; one case after each of the following: 2-year-leys, 3-year-leys, and flax; and no cases

after beans and old turf respectively. These figures show that in 1948 Take-all was most prevalent after wheat or barley and after a fallow following wheat or barley, and was much less prevalent after other croppings. Analyses of crops further back in the rotations showed that there was on the average no appreciable Take-all in fields which had had on the average one wheat or barley crop every three years, and very little when two of these crops had been taken every five years. When a wheat crop was taken on the average every other year there was a considerable risk of Take-all.

Conclusions

The conclusions to be drawn are as follows :—

1. 1948 was a Take-all year in the South West. The weather conditions were remarkably favourable to the disease, assisting carry over of the fungus on the stubbles and its growth along the roots of the wheat seedlings, and in checking the growth of the wheat plants.

2. It was clearly demonstrated that continuous cropping with wheat and barley favoured the disease, whereas an average of one wheat or barley crop every three years resulted in a low incidence of Take-all.

3. A large number of the cases of Take-all followed bare fallows after wheat or barley. These were probably due either to the carry over of the fungus on perennial weed grasses in the fallow, or to failure of infected stubbles or sods from the previous season to rot, owing to dry soil conditions in the latter part of 1947, loose soil texture and possible accumulation of nitrogen in the fallows.

4. It may be asked whether Take-all will recur to such an extent next season. The large amounts of diseased stubbles in the fields constitute a dangerous source of infection. On the other hand wet and mild weather after harvest, favouring rapid disintegration of the stubbles and subsequent consolidation of the seed beds, and weather conditions favouring rapid and uninterrupted growth in the spring may largely militate against disastrous results next year, provided rotations are planned carefully and the crop is manured adequately. It would appear from all the evidence available that in the South West a 3- or 4-year-ley is the best safeguard after a crop severely affected with Take-all.

